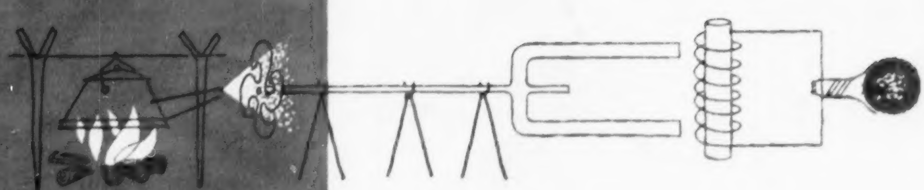
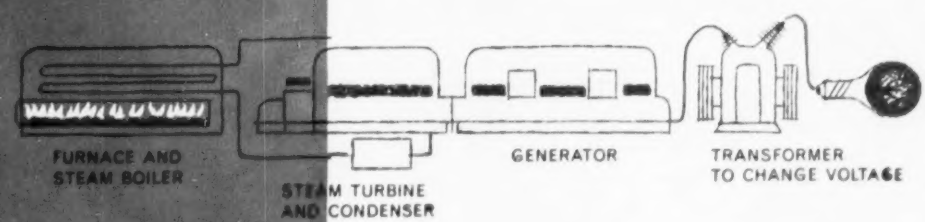


Nuclear Power:

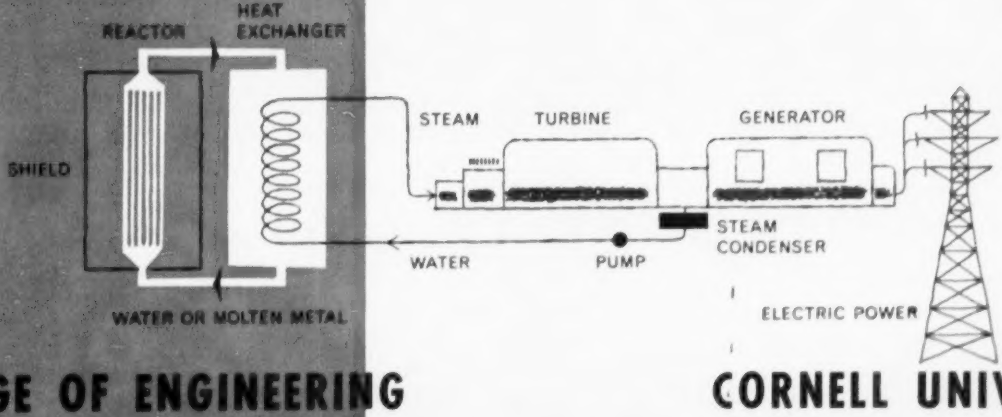
Cornell's Research Reactors For Nuclear Technology

Controlled Nuclear Fusion



The Cornell engineer

MAY, 1958
VOL. 23, NO. 8
25 CENTS



COLLEGE OF ENGINEERING **CORNELL UNIVERSITY**

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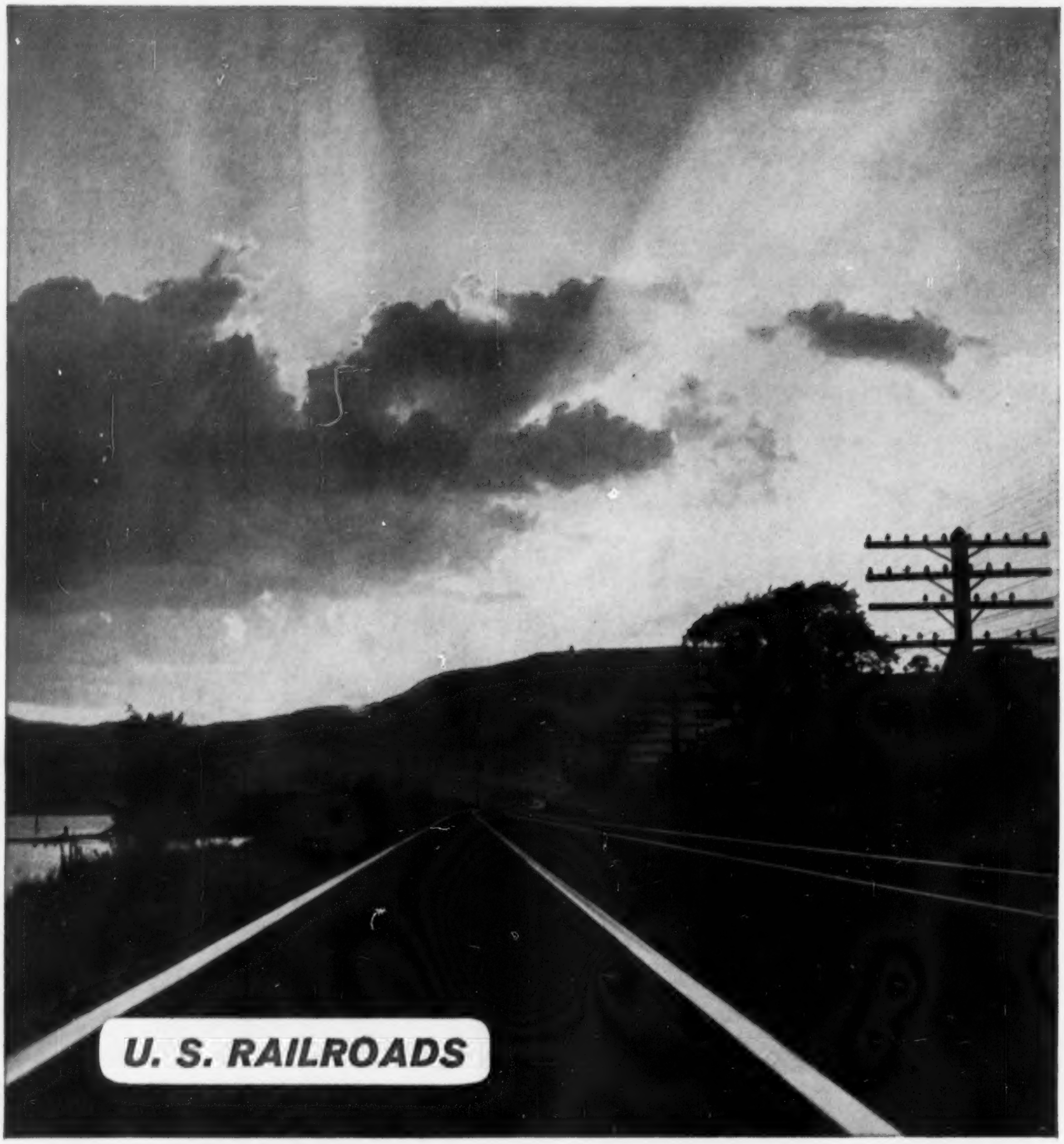
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THE CORNELL

engineer

MAY 1958 VOLUME 23 NO. 8

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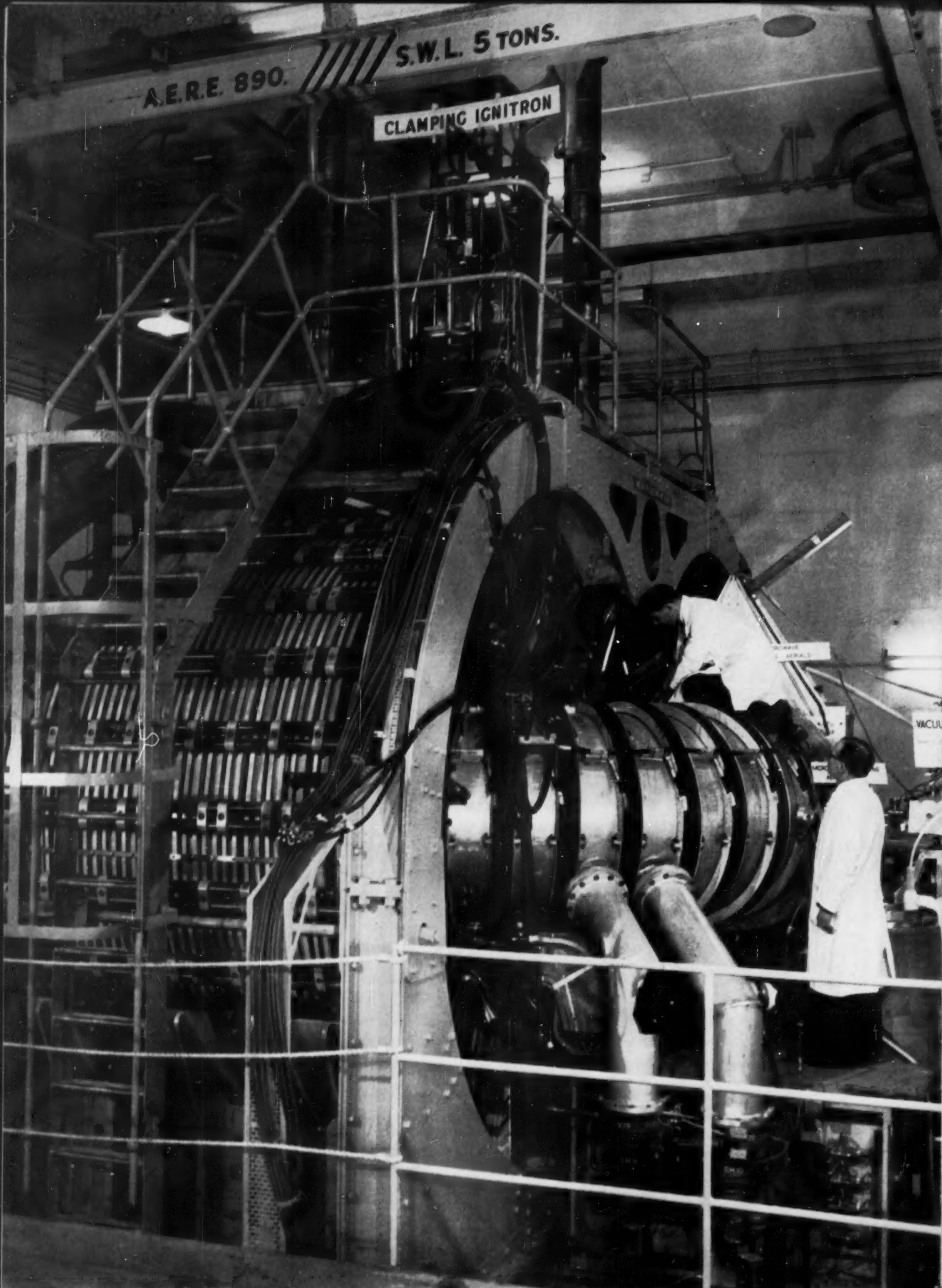
Diagrams courtesy of the Edison Electrical Institute

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Carpenter Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers $3.00; student $1.50; single copy $.25.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CLAMPING IGNITRON

CONTROLLED NUCLEAR FUSION:

the promise of tomorrow

by Roy J. Lamm, ChemE '61

For billions of years the sun's fusion reaction has provided this planet with energy. A few years ago man learned how to create small suns of his own which could destroy entire cities in less than a second employing the same fusion reaction. Now a joint British-American announcement on progress of research in controlled nuclear fusion has raised hopes that the devastating power of the H-bomb can be harnessed to provide civilization with an *ultimate* source of energy.

Such a source would be virtually inexhaustible, for deuterium (heavy hydrogen), the only fuel needed in fusion, is present in abundant amounts in sea water. It is estimated that a half pound of deuterium a day would provide over a million kilowatts of electric power. With our energy demands increasing at a rate much faster than our fossil fuel reserves and our supply of uranium used in atomic fission power plants sharply limited, it is little wonder that the British - American announcement made in January attracted such world-wide attention.

The British at Harwell and the United States' researchers at Los Alamos stated that the work they have done thus far is mostly exploratory in nature and that actual controlled fusion might take five to ten years to accomplish in the laboratory and an additional twenty to thirty years to accomplish in a large scale power plant. This great length of time is indicative of the many obstacles confronting the scientists involved in this project.

Zeta (Zero Energy Thermonuclear Assembly), the Harwell apparatus in which experiments towards controlling fusion have resulted in temperatures of 5 million degrees Centigrade being achieved for millisecond periods.

United Kingdom Atomic Energy Authority

Tremendous Temperatures Required

Basically the fusion reaction consists of the coupling of four ordinary hydrogen nuclei to form a helium nucleus with an atomic mass slightly less than the sum of the atomic masses of the four hydrogen nuclei. This difference in mass (seven tenths of one per cent of the atomic mass of a hydrogen nucleus) appears as energy in the form of light and heat. On the sun 600 million tons of hydrogen fuse per second yielding 596 million tons of helium plus tremendous quantities of energy.

Because the process of fusion of ordinary or "light" hydrogen which takes place on the sun requires a cycle of millions of years, it is not possible to use ordinary hydrogen on earth where a fusion reaction must take place in seconds. Only deuterium with a mass twice that of hydrogen and tritium with a mass three times that of hydrogen can be used.

The roadblock to any man-made fusion reaction is that temperatures of over 100 million degrees C. are needed to initiate a self-sustaining deuterium "fire." In the H-bomb this is accomplished by exploding an A-bomb within the weapon. Obviously this method could not be employed in a fusion reactor. Thus machines have to be developed that can generate such temperatures from electric power.

Present Reactors Insufficient

The vessels created thus far are the United States' Perhapsatron and the British ZETA (zero energy thermonuclear assembly). These, however, can produce only a fraction of the self-sustaining temperature. The latest Perhapsatron, smaller than the Zeta but of similar design, consists of a glass or quartz torus or doughnut about forty inches in diameter which serves as a gas

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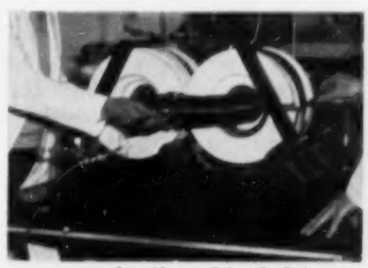


Los Alamos Scientific Laboratory

The latest Perhapsatron. Notice the solenoid winding around the torus, a feature absent from the earlier model.

University Plans Million Dollar Reactor Construction

NUCLEAR TECHNOLOGY AT CORNELL

by

Robert M. Bryant, ME '59 and Joyce A. Myron, EP '61

At no other time in history has the role of the scientist been so greatly stressed. Nuclear technology in particular, although the newest of the applied sciences, is of world concern, and the demands upon the skill of the nuclear scientist are rapidly accelerating. In order to continuously provide personnel trained in the latest techniques and developments, engineering schools all over the country are reviewing their programs and altering them to meet the challenge.

Cornell University, in keeping with the trend toward modernizing technical curricula, has established an elective program in nuclear technology available to all undergraduates in the Engineering College. The purpose of this training is to prepare the engineer in any field for the specialized conditions met when dealing with nuclear installations.

Nuclear technology is not a separate branch of engineering but rather it combines the skills of existing engineering disciplines. For example, the mechanical engineer finds problems of heat transfer, fluid flow, and mechanical design; the civil engineer meets with unusual structures and the disposal of radioactive wastes; the electrical engineer devises automatic and remote controls and integrated power systems; the chemical engineer faces corrosion, fuel processing, and the preparation of wastes for disposal; the metallurgical engineer works with unfamiliar materials; and the engineering physicist creates new reactor concepts. Other problems are the effect of radiation on the materials used for the machines, structures, and electrical equipment in nuclear installations.

In order to properly instruct engineers in this new technology the University has installed extensive nuclear facilities and has many others in the offing. But before considering Cornell's present and proposed nuclear facilities, it will be beneficial to discuss nuclear reactors in general. In this way, the highlights of the Cornell program will be more fully appreciated.

Professor David Clark, who will be in charge of the Cornell Reactor Project.

Reactor Concepts Simplified

A nuclear reactor, regardless of design, consists of four basic parts: fuel elements, moderator, shielding and control system. Fuel elements are composed of a variety of materials having the property of being fissionable. Natural uranium, which contains one part of U-235 to 140 parts U-238, or U-238 enriched with U-235 usually comprises the active member of the fuel element. The elements may be fabricated in several ways. Two common forms are slugs and sandwiches. The slugs, or pellets, are small uranium cylinders stacked in a watertight aluminum tube approximately five feet in length. In the sandwich process, sheets of uranium-aluminum alloy are pressed between layers of aluminum cladding.

The neutrons emitted in the fission process must be slowed in order to achieve a sustained reaction.[1] A medium which decreases

[1] One notable exception is the fast breeder reactor, which makes use of "fast" neutrons. This topic is beyond the scope of this discussion.

the velocity of the emitted neutrons is known as a moderator. It may also be composed of various materials. The first reactor to achieve a self sustained chain reaction, the graphite pile at the University of Chicago which went critical December 2, 1942, used graphite of unusually high purity as the moderator. However, other substances, such as light and heavy water, have been found suitable and now are in common use.

Shielding is a protective measure to prevent radiation from penetrating into work areas. Elements of high atomic weight are suitable for this purpose. Although lead is commonly known to be an effective shielding medium, cost and weight considerations have led to the use of reinforced concrete and suitable depths of water.

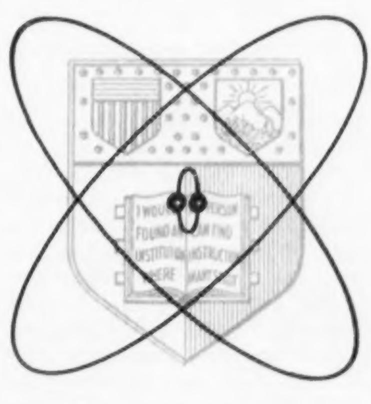
Control of a nuclear chain reaction is achieved by absorption of the slow neutrons. Materials with a high neutron cross section (a measure of neutron absorption capacity) in the low energy regions, such as cadmium, boron, iron, and hafnium can be fabricated into rods for control purposes. These rods, placed throughout the lattice of the core, can be advanced or withdrawn, thus inhibiting or promoting the chain reaction as desired.

Sub Critical Reactor

At Cornell the facility for training engineers for work in nuclear technology has been a sub-critical assembly. In such a unit the fuel elements, though composed of fissionable material, do not provide enough neutrons to cause a sustained reaction. In this case the multiplication factor, which represents the ratio of the number of neutrons of any one generation to the number of the immediately preceding generation, is less than one. The Cornell assembly has an effective multiplication factor of 0.85.

The Cornell sub-critical assembly is the major apparatus for a nuclear measurements laboratory course and supplements the entire nuclear technology program. Immediate supervision is under the Department of Engineering Physics with Dr. Trevor Cuykendall as head of the Department, and Dr. David Clark as the chairman of the nuclear physics curriculum committee. Acquisition of the assembly was made possible by a generous A.E.C. loan of 2.75 tons of uranium and a 25 curie polonium-beryllium neutron source, under one of the A.E.C. programs of assisting education in nuclear engineering.

Structurally, the facility is built in an open cylindrical steel tank, four feet in diameter and six feet high. Uranium slugs in groups of six are encased in capped aluminum tubes 56 inches in length. There are about 200 such rods which are held vertically in a hexagonal lattice by an adjustable system of guide bars and pins. The lattice unit is surrounded by an aluminum tank which is nested in the larger tank. Either both tanks or just the inner tank alone may be filled with ordinary water. Since the spacing of the lattice is continuously adjustable, the pattern of loading may be changed and it is



possible to operate with water-uranium volume ratios from 0.5 to 3.0 or more. The entire assembly is located on top of a concrete pedestal with a cavity in it directly below the inner tank. This cavity may be filled with moderating material provided with a slot for the neutron source so that the assembly can be irradiated from below.

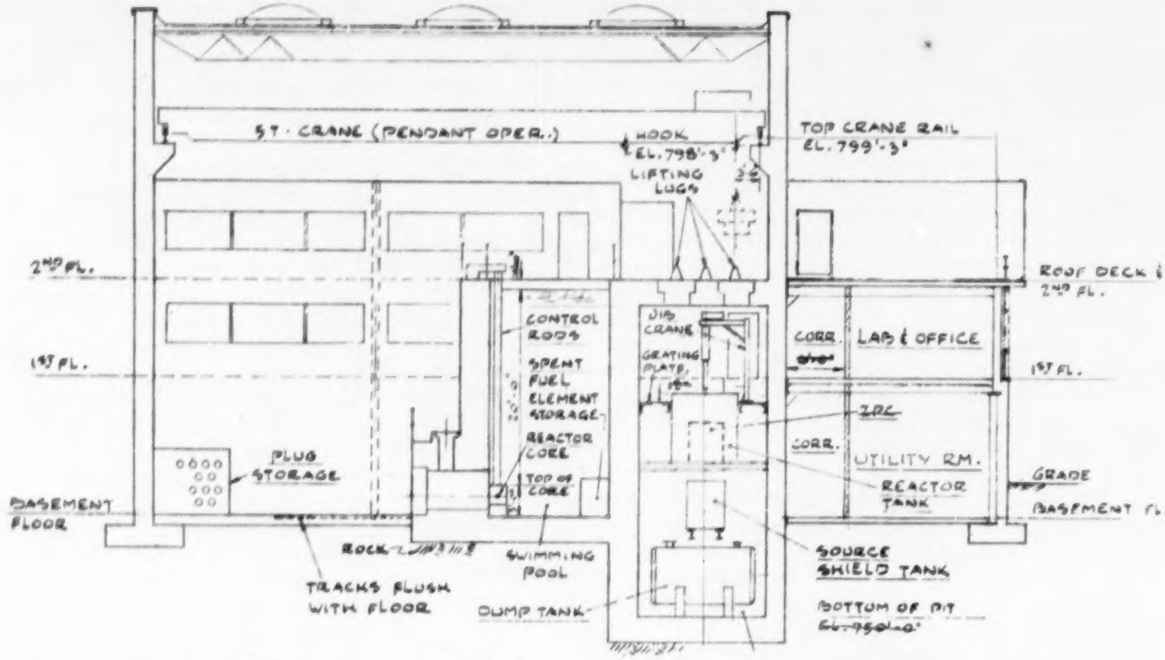
This facility contains some special features which are of interest. First is the unusually large flexibility for changing the lattice spacings and patterns. Another feature is the ability to produce low neutron level "beams" through two aluminum ports. Since the lattice exists in a separate inner tank, it is possible to operate it as a reflected reactor as well as bare. Although not necessary for the operation of a sub-critical assembly, cadmium rods or sheets can be inserted into the pile to illustrate control action.

New Reactors Planned

These and other characteristics permit the sub-critical assembly to fulfill a twofold purpose: teaching and minor research. But the scope of reactor technology which can be illustrated by a sub-critical assembly is limited. The University, recognizing this, appointed a faculty committee to study the long range needs of the Cornell nuclear program. In May 1957, the committee advised the acquisition of a low power teaching reactor and a high flux research reactor. Two reactors instead of one were recommended since a low power, relatively flexible and accessible reactor has distinct teaching advantages, while the high flux reactor would provide a neutron source intense enough to permit research in such vital fields as radiation damage, neutron diffraction, neutron cross-sections, etc. A single unit combining both functions would possess such conflicting design requirements that neither purpose could be adequately achieved.

The first step in Cornell's facilities expansion program is to provide the low-power reactor for higher quality student instruction. The proposed reactor for this purpose is a dual-core facility whose conceptual design was developed by members of the Cornell faculty.

Dual-core, as the name implies, consists of two cores, an intermediate power "swimming pool" core and a "zero power" core. The swimming pool will be used for a multitude of purposes, including pile oscillator and operational studies as well as a source for an intense supply of neutrons. This unit resembles the Naval Research Laboratory reactor in that it is rigidly fixed in a graphite niche, surrounded on the three vertical faces by graphite and on the fourth by demineralized light water. This water will also serve as an internal moderator. The pool in which the core is to be located will be twelve feet by eleven feet in cross section and approximately twenty-three feet deep. Thus the reactor will be submerged a minimum of eighteen feet. Radiation above the pool will be reduced to negligible amounts by this ample water shielding, allowing the pool to be operated safely at all its power levels. Maxi-



Cross-section, looking North, of the Cornell Reactor Facility. Some details of the "Swimming-Pool" type reactor are shown.

mum power level for this apparatus is ten kilowatts. Fuel elements will be fully enriched uranium-aluminum alloy sandwiches.

The dual-core unit is primarily a teaching aid and at all times instructional activity will have priority over research activity. The swimming pool core is particularly intended to fulfill the function of acquainting the student with a true reactor. This will offer the student an opportunity to investigate the use of radiations from the reactor for laboratory experiments, as well as give him a first hand look at the starting up, operation, and shutting down of a reactor. Advanced graduate students will be permitted to operate the reactor under the supervision of a licensed operator. There will be some work done in other fields, too, such as irradiation of biological specimens and use of reactor-produced isotopes.

The other member of the Cornell duo will be a zero power core, which will operate at power levels below ten watts. This unit will be nearly identical in size and function to the Westinghouse Bettis Plant and Brookhaven National Laboratory setups. However, Cornell's zero power core is unique in that it is the first such assembly to be constructed by an educational institution. The fuel elements will be rod type, and like the subcritical assembly they will be easily arranged in different lattices. The zero power core will be housed in the same three-story building as the swimming pool, the reactor tank itself being on the upper floor and a 2000 gallon dump tank directly below it. The seven foot diameter reactor tank will contain light water as moderator and reflector. The water will be stored in the dump tank and pumped to the reactor tank when needed. Controlling the core will be four cadmium rods remotely controlled by a system similar to that used in the swimming pool reactor. The reactor will be started up by a polonium-beryllium neutron source, which is then stored in the dump tank.

This facility will serve the purpose of carrying on laboratory work beyond the scope of the sub-critical assembly. With this unit students can gain experience in nuclear measurements such as control rod calibration and temperature coefficients of reactivity as well as studying the approach to criticality. Another important use of the zero power core will be to aid study of reactor physics above the undergraduate level.

Although the dual core reactor is the chief constituent of the proposed nuclear facility, a gamma radiation cell will also be built under the direction of Dr. Robert L. Von Berg of the School of Chemical Engineering. This will be housed in the reactor building and will make use of spent fuel elements and a cobalt 60 source. With this apparatus studies can be conducted into the effect of gamma radiation on materials. It will also be used extensively for radiation effects on chemical reactions.

With the building of Olin Hall in 1941 and the rapid building rate of the past five years, the engineering quadrangle has undergone a gradual shift from the north end to the south end of the campus. The as yet unnamed reactor facility will also be located at the south end of the campus, behind Kimball-Thurston Hall near Cascadilla Creek. The building itself will actually consist of two main sections, the reactor housing and a wing which will contain the gamma cell, service rooms, classrooms, laboratories, offices and a counting room. Both units are coordinated in a modernistic circular design which will blend harmoniously with the architecture of the quadrangle. The reactor housing of cylindrical shape will be sixty-four feet in diameter with the auxiliary unit twenty-two feet in radial width.

Curriculum of the Nuclear Option

The present curriculum, inaugurated in 1955-56, consists of an elective sequence of six courses which are taught in several departments of the Engineering College. This sequence is outlined below:

Course	Number	Term
Atom, Nuclear and Electron Physics	P 214	8
Nuclear and Reactor Physics	EP 8311	9
Nuclear Measurements Laboratory	EP 8351	9
Advanced Heat Transfer	ME 3665 or ChE 5505	10
Nuclear and Reactor Engineering	ChE 5760	10
Reactor Theory	EP 8312	10

Material relating to nuclear technology is also incorporated in less specialized courses in the sanitary, metallurgical, and chemical engineering programs. Since nuclear engineering is considered an extension of the other branches, no separate department or degree in nuclear engineering exists or is planned. Because of growing student interest, additional courses are being planned. These include a metallurgical engineering course on materials used in reactors, a course in thermonuclear power and an advanced reactor theory course. Formal adoption of these courses has not taken place as yet, but it is expected that most of them will be available in the 1958-59 school year.

Funds Still Being Raised

The financial aspect of this project will be of interest to former and future graduates alike. Total cost for the entire facility is estimated to be approximately $1,200,000. Application has been made to the AEC for an amount which will be applied toward the swimming-pool portion of the unit. The cost of the dual-core reactor will be approximately $600,000. The bulk of the necessary funds is being sought from private donors. The time schedule for the construction is dependent upon fund-raising. However, a preliminary estimate of the completion date is Spring 1960.

The Vitro Engineering Company of which J. Carlton Ward, Chairman of the Cornell Engineering Council, is president has been of great assistance to this project. At a minimum cost to the University, Vitro enthusiastically joined with the Cornell faculty in developing preliminary designs.

Administration of the reactor facility will be through the Department of Engineering Physics and will be under the direction of Dr. David Clark. Dr. Clark with his

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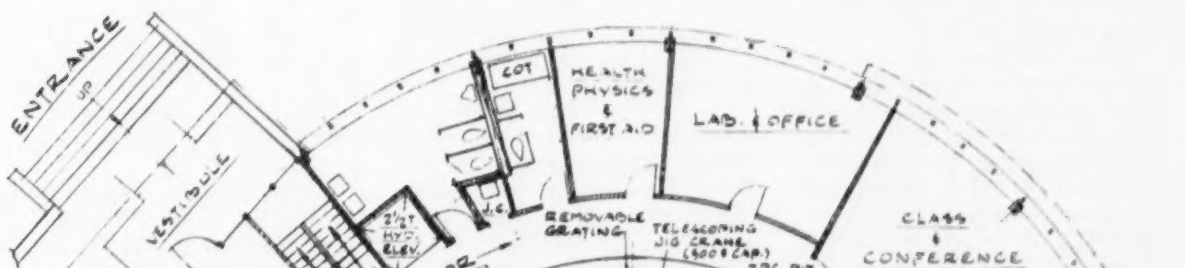


Main Floor of the Cornell Reactor Facility. The reactor building will be constructed to be virtually air-tight.

THE SAFE DISPOSAL OF RADIOACTIVE WASTES

by Lawrence A. Wheeler, ChemE '62

The efficient disposal of waste material has been a problem which has plagued mankind since the earliest civilization. In recent years, science has been confronted with a radically new disposal problem which endangers not only our generation, but generations to come. This is the problem of radioactive waste disposal.

During the war, all emphasis was placed upon the production of fissionable material to be utilized in a weapon of destruction. The effective treatment of radioactive waste material was postponed until the prime objective was accomplished. With the advent of peace, it was discovered that radioactive waste disposal posed quite a problem when industry employed atomic energy. Temporary solutions such as venting gases to the atmosphere through tall stacks, burying solids in waste land areas, and holding liquid wastes in underground retention tanks, were found quite satisfactory; but it became evident that more efficient means of radioactive waste disposal would have to be devised as the accumulation of such waste increased.

Radioactive waste material can be divided into three categories: air-borne wastes, liquid wastes, and solid wastes. The air-borne wastes generally consist of such radioactive gases as tritium, krypton, and iodine. These gases diffuse almost immediately and present no subsequent problem as long as high stacks, not immediately upwind from an inhabited area are used. Liquid wastes consist of radioactive elements, formed in the fission of fuels, with mass numbers from 70 to 162 and half-lives ranging from seconds to hundreds of years. These pose the most serious problems and will be dealt with in detail. Solid wastes include chiefly large volumes of equipment and miscellaneous supplies. The problem here is not the high activity involved but the great bulk of material which must be handled during decontamination.

Alternate Solutions

There are three prevailing philosophies concerning the proper solution to the waste disposal problem: dispersal, controlled containment, and partially controlled containment. Disposal by dispersal relies upon the adequacy of mixing the waste with large volumes of air or water. This system is satisfactory as long as waste quantities remain small. Obviously, it is the cheapest and easiest way.

There is also the theory that no radioactive wastes should be released from the control of the producer. This method entails the bottling and deposition of contaminated liquids in underground containers. This is a satisfactory solution as long as the amount of material remains small, but there is always the danger of tank rupture or deterioration.

Then there is the process of storing the waste in a place where the escape rate is not controllable but is believed to be low. The burial of solids in trenches and underground cribbing of liquid wastes leaves the radioactive substances open to leaching by ground water, but sites can be selected where this effect is very slow. The selection of one of these philosophies or a combination of them is essential in determining how the long-term waste disposal problem will be handled.

Gas Disposal

The bulk of gaseous waste comes from hood and cave exhausts. All operations employing radioactive materials are done in hoods and the exhaust may run from one thousand to several thousand cubic feet per minute.

A typical gaseous disposal operation is the disposal of these exhaust gases at Argonne National Laboratories. The air that enters the hood is prefiltered, and at the back of the hood are fiberglass filters that even out the air flow and act as prefilters for both dust and radioactivity. The exhaust gases are conducted through an AEC filter (a highly retentive paper asbestos filter) before reaching a blower which discharges them through 3 foot wide stacks on the roof.

Special treatment is required for the gases resulting from much larger scale chemical operations. A caustic bath scrubber is used to remove chemical fumes and radioactive gases such as iodine. The scrubbed gas is then conducted into the cell exhaust, filtered and vented through stacks. At Oak Ridge, a tower unit which utilizes the reaction between iodine and silver nitrate is capable of removing I^{131} from gas streams with an efficiency of 99.99 per cent.

As has been previously stated

the disposal of gaseous wastes does not present a serious problem now or in the future. Since disposal is largely by dispersal and dilution, precaution must be taken to see that the wastes do not become too concentrated in the diluent; however, with proper handling and good industrial practice, there should be no difficulty in this procedure.

Liquid Disposal More Difficult

The disposal of liquid wastes presents a very complex problem. In this category fall the radioactive drainage from laboratory sinks, the liquid waste from bench scale and pilot-plant, and metallurgical equipment that is usually radioactive. The methods of handling liquid wastes consist of evaporation, ion exchange, flocculation and filtration, and solidification.

The problem of liquid waste disposal becomes increasingly important at production sites. It has become common practice to store the wastes in buried steel or concrete tanks, whose construction costs range from twenty-five cents to two dollars per gallon of waste. These tanks, however, are always subject to rupture and it is inconceivable that they should be sufficiently corrosion resistant to last indefinitely. At the Hanford Atomic Laboratories, the semi-arid conditions have so dried the soil that appreciable quantities of liquid may be added before the liquid penetrates to the water table; the flow of the underground water is so slow that it takes months to years for the water to flow from the disposal site to the river.

In areas where there is not a large amount of space for burial available, and with the realization of the high cost of storage, it becomes evident that the bulk of the waste material must be reduced considerably. The most widely used technique for concentrating the liquids is the process of evaporation. A typical primary evaporator consists of a steam chest, separator chamber, overhead condenser, constant head feed tank, and control instruments. The vapor and entrained liquid leave the steam chest via a centrifugal separating section and enter the separator. The entrained liquid is caught in this chamber where natural circulation returns it to the steam chest. The vapor passes through the separator vapor space and is more completely deentrained by a centrifix scrubber. The vapor is then condensed in the triple-pass surface condenser and returned to a storage tank for monitoring.

A wide range of flocculating agents is in use but the decontamination process is not as efficient as in other methods. The advantages of the process are low cost, the ability to handle a wide range of solid content in the feed, and the production of a waste floc volume which is relatively independent of feed solid content; however, after careful study it has been concluded that as a method for handling high level wastes, flocculation is unsatisfactory.

At Hanford, ion exchange is an important process for the disposal of low intensity wastes. The wastes are pretreated by passing through a bed of calcium carbonate to adjust the pH to the range of five to nine, which is optimum for minimum leaching of the soil and for maximum ion exchange capacity for those ions of most concern. The wastes contain radioactive ions at very low concentration. The most hazardous ions, cesium and strontium, are retained by ion exchange in the soil. An installation of this type is used until the ion exchange capacity of the soil is exhausted with respect to the cesium and strontium. Sodium, nitrate, and ruthenium move through the soil more rapidly than other contaminants and act as leaders to predict the time of appearance of more hazardous ions in the ground water. As the concentration of cesium or strontium reaches one-tenth of the maximum permissible concentration for drinking water, the site is abandoned in favor of a new one. Higher intensity wastes are scavenged to as low a concentration of hazardous ions as possible and then are distributed uniformly throughout a trench in such a quantity that significant amounts of the liquid never reach the water table.

All these solutions are working satisfactorily at present, but it is evident that there are many unknown factors concerning the long-term movement of radioactivity into the ground water. Much work must still be done on this problem.

Brookhaven National Laboratory

Scene at Floyd Bennett field, Brooklyn, as steel drums containing radioactive waste from Brookhaven National Laboratory, Upton, N.Y., are taken aboard an LST for burial at sea.

Brookhaven National Laboratory

Burial of highly contaminated heavy machinery from chemical separations plant at Hanford. Cost of decontamination plus repair would exceed replacement cost.

Solids

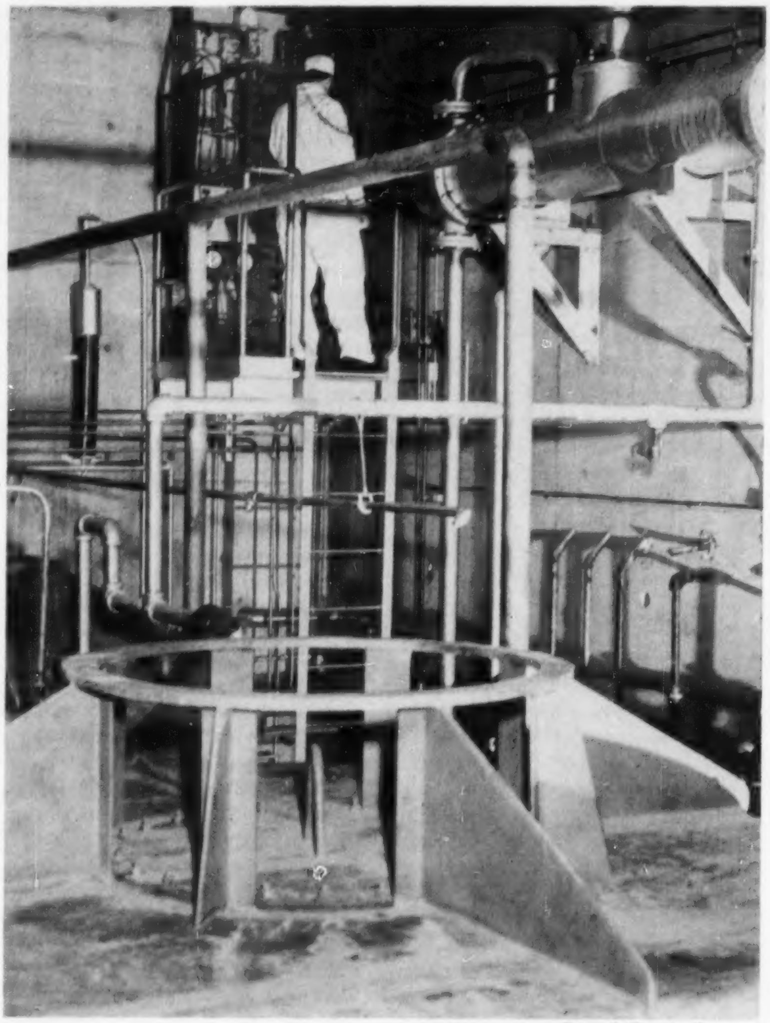
As was previously stated, the problem with solid waste disposal is not the high activity but the large bulk of material involved. At Los Alamos, burial is the method chosen, because of the large amount of arid land with soil and rock conditions such that one need not fear seepage into underground water supplies. The material is usually placed in pits in sealed containers, and a record is kept of the location in the pit of each load of material.

At Brookhaven the situation is somewhat different, and the most practical method is to concentrate, package, and transport all except low level wastes to a shipping port where they are loaded aboard an LST and finally dropped overboard into 7500 feet of water some 150 miles from shore. Concentrated wastes are mixed with Portland cement so that they set to a mortar, and the activity is thus made less mobile.

At Argonne, to reduce the high cost of storage, all combustible material is put through an incinerator which reduces the waste to radioactive gases and ashes. The gases are scrubbed and filtered before discharge, and the ashes are collected and stored with the noncombustible waste in a storage area consisting of concrete lined trenches with removable wooden covers. The bins in which they are stored are of such a size that eventually they may be covered, loaded on railroad cars, and shipped to a national graveyard if one is eventually set up.

Disposal At Sea

The large quantities of water needed to dilute strontium and cesium isotopes is the greatest drawback to disposal of radioactive wastes at sea. It requires 2.6 x 10^7 cubic miles of water (about five per cent of the entire world ocean volume) to dilute strontium-90. Glueckauf at the Geneva Atoms For Peace Conference suggested that strontium and cesium be separated out and stored separately. The remainder of the waste would then be stored in tanks for thirteen years and then discharged at sea. The only problem here is that this separation must be extremely quantitative, since leaving as little as .0001% of the strontium-90 with the other activity will cause the storage requirement to be raised about a century.



General Electric Company

Concentration of wastes through evaporation of excess water has saved millions of dollars at Hanford by reducing the number of storage tanks required. Part of evaporation equipment is seen here.

There is no information available regarding the amount of diffusion of radioactive particles in the ocean and there is always the danger that these particles could become concentrated at one particular location and thus endanger both human and marine life.

Future Refinements Necessary

Improvement in waste disposal practices is being sought in several areas. There has been much written about the feasibility of using fission product wastes for industrial purposes, so that their radioactivity could be put to some advantageous use; however, this does not eliminate the problem of final disposal after the material is no longer industrially useful. There has also been much research concerning a new method of changing reactor heat to electricity and eliminating many of the heat dissipation problems. Another improvement was recently proposed at Hanford, where it was found that radioactive solids could be encased in a gel-like substance instead of using costly steel tanks.

The methods for waste disposal now in operation have proved satisfactory for our generation and have aptly protected the public from any danger. It is hoped that science will find better solutions to the problem as the increased use of atomic energy creates much larger volumes of waste than can be handled by methods now in operation.

CONTROLLED NUCLEAR FUSION

(Continued from Page 11)

tight container for the deuterium gas and as an insulating wall between the gas discharges and the metal torus surrounding the glass. This second torus of aluminum or copper serves as the primary of a transformer. The deuterium gas within the glass acts as the secondary of this transformer. Around the metal is a solenoid winding which produces an axial magnetic field about the deuterium to keep it from distorting and twisting during a "pinch." Inserted through the torus is an iron core which improves the transformer coupling between the metal primary and the deuterium secondary.

Deuterium gas is fed into the glass torus where a relatively small current ionizes it into negative electrons and positive protons. The ionized deuterium is commonly referred to as plasma. An extremely large current is fed into the metal primary resulting in a large induced current in the plasma, thus raising its temperature to five or six million degrees centigrade. Because no refractory could possibly withstand such temperatures, scientists have had to resort to a "magnetic bottle" which pinches the plasma into a narrow column in the center of the glass torus. The "magnetic bottle" results from the strong magnetic field existing when current flows in the outer metal torus.

The apparatus, glass torus, metal torus and iron core but not the solenoid winding, had been yielding "pinches" of six million degrees centigrade which lasted for a few millionths of a second before the plasma broke away from the bottle and slammed against the glass wall.

The British have recently made somewhat of a breakthrough by installing the solenoid winding which has suppressed distortions in the pinched column of plasma long enough to produce a pinch of five million degrees centigrade for five thousandths of a second.

But this must be regarded as a minor accomplishment toward controlled fusion when it is realized that plasma must be held together for seconds at temperatures twenty times those obtained thus far in order to obtain a self-sustaining deuterium fire. Larger equipment of better design will have to be developed. This will take a great deal of time and money.

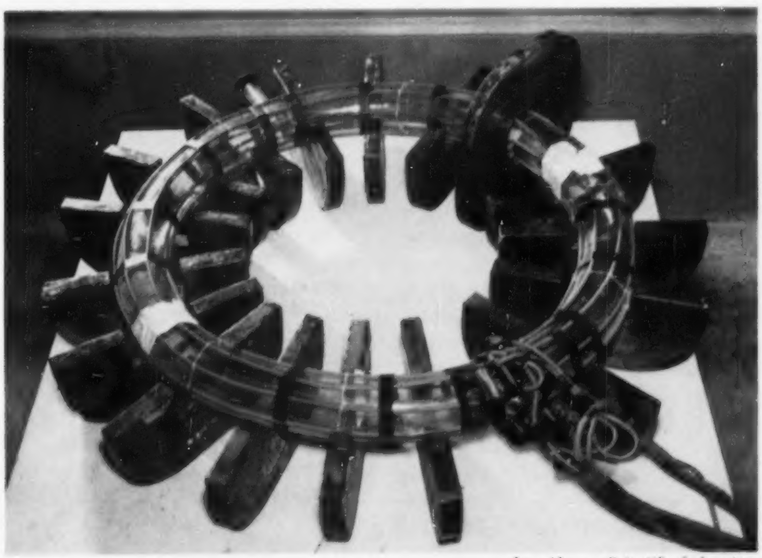
Unlimited Power to Bring Changes

The era of fusion power will change many of our present concepts and solve some of our present problems. With the cost, size and weight of fuel negligible, five gallons of sea water can provide as much energy as about ten tons of coal, economic considerations will favor large power plant installations —larger than any now known. The major cost of power will then be transmission. Completely new transmission systems will have to be explored. Perhaps induced fields will be used for short distance transmission and electromagnetic radiation for longer distances.

With unlimited power, seawater can be purified and used to irrigate the vast stretches of arid land in the world. The increasing problem of overpopulation in the world will then be solved.

Perhaps controlled fusion will even yield a power plant capable of propelling large payloads of men and equipment into outer space for exploration.

At present controlled fusion is only a scientist's dream. A dream, however, which they believe someday can be realized. Until that day arrives, it remains the promise of tomorrow.



Los Alamos Scientific Laboratory

An early Perhapsatron. Primary windings and iron cores used to heat the deuterium gas are shown around the discharge tube. Researchers are attempting to heat the gas to temperatures of about a hundred million degrees, and at the same time confine it in the tube for sufficient time to allow fusion reactions to take place. A major research effort is study of the "Pinch", which utilizes electromagnetic forces to pinch the gas toward the center of the tube, thus compressing and heating it.

NUCLEAR TECHNOLOGY

(Continued from Page 15)

reserved, sincere and, as those students and colleagues who associate with him realize, inspiring manner had the following to say on Cornell's nuclear program:

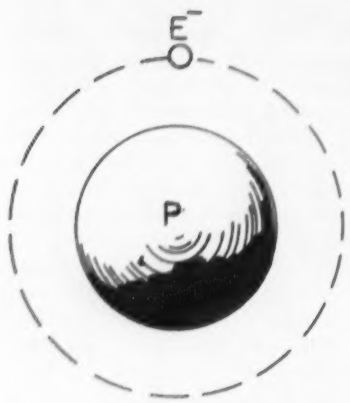
"The aim of the College in developing courses and laboratory facilities is to provide a comprehensive program of instruction in this field. Interested students from any of the Schools of the College are offered the opportunity to learn the fundamentals of nuclear technology. In addition specialized and advanced courses in many phases of nuclear engineering are available or are planned. For example, reactor physics—the physics of reactor cores—receives considerable emphasis in our planning, and especially in experimental reactor physics we intend to offer a more thorough training than is planned at most other universities.

"The dual-core reactor now under design will be the heart and focus of the entire program, and will enrich and support both introductory and advanced laboratory work. It is in fact an indispensable facility for the strong educational program Cornell is developing."

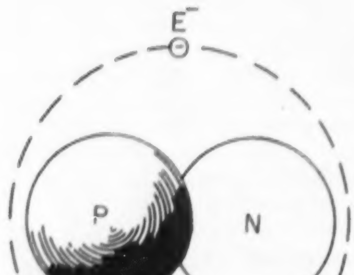
ENERGY AND THE ELEMENTS

by

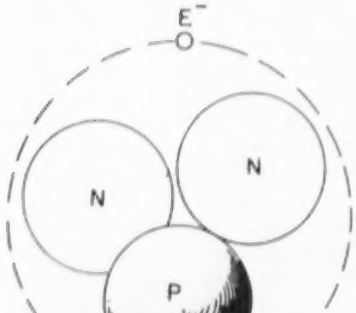
Yasha Yavitch, B.M.E. '28; M.M.E. '33



Hydrogen



Deuterium



Trilium

Robert Franson

Shown here are schematic representations of Hydrogen and its isotopes.

Since the day man first started living on this earth, he has been searching for methods to ease his burdens and provide more comforts for himself. His search has centered primarily around the utilization of the elements of his environment to yield energy—energy which his body was unable to provide to carry out the dynamic conceptions of his mind. Almost every major advance in his existance can be traced to a discovery of a new way to get more energy from the ninety odd elements that make up this planet.

Man's first discovery, and probably his greatest, in this search was the secret of fire. Fire is the fusing of the element carbon with the element oxygen quantitatively expressed by the equation:

$$q + C + O_2 \rightarrow CO_2 + 14{,}600 \text{ Btu/lb.}$$

The "q" term is the ignition or kindling temperature required to initiate the fusion.

Soon after this initial discovery, man domesticated animals. Using the energy of the sun, he raised hay to feed his horse or burro which in turn provided the power necessary to do some of his chores.

These primitive sources of energy sufficed for thousands of years until man discovered that he could burn solids and liquids that had stored some of the sun's energy in them millions of years before and use this resulting energy in heat engines. These devices, most notable among them being the internal combustion and steam engines, multiplied the power at his disposal a thousand fold and thrust him into an accelerated period of scientific and technological achievement.

However, having developed such machines, we today find that we have built a civilization upon them which has an insatiable thirst for energy. A thirst increasing at such a rate that in a hundred years we will be using 1000 times as much energy as we use today. At this rate our oil reserves would last only a few months and our coal reserves only a few years.

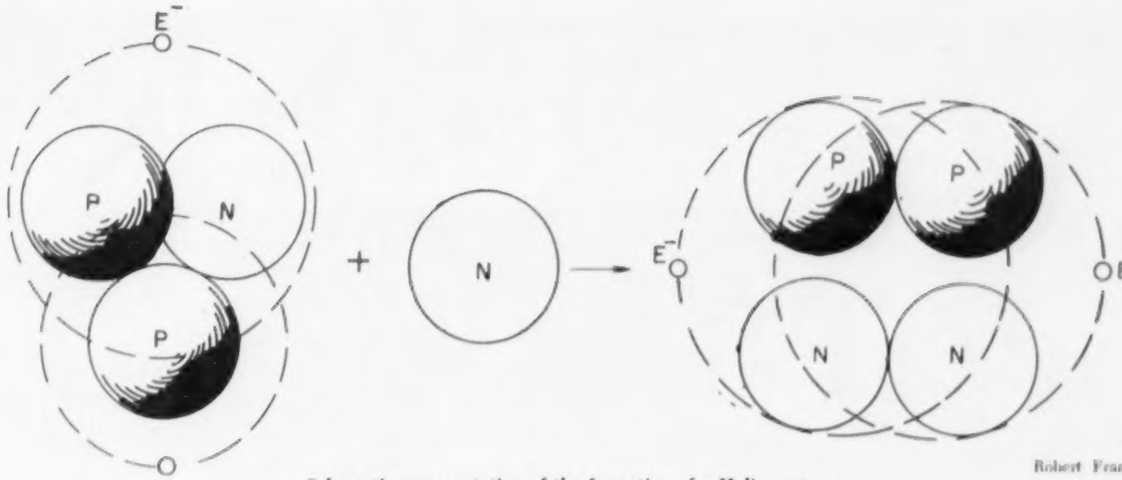
Realizing this impending danger, we have been intensively reinvestigating the elements around us in an effort to find new energy sources. This new search has already brought about the employment of nuclear fission as an energy source and portends to make available even greater energy sources in the near future.

Fission Is Inadequate Power Source

In the fusion of carbon with oxygen with the resultant meagre liberation of heat, we are fusing atoms to form a new atom. The result is a rearrangement of the atoms' electrons. This superficial fusion results in superficial heat release. This type of fusion is the art of the chemist. The chemist considers the atom of any element a microscopic entity.

The physicist, however, has discovered that the atom is a macroscopic system of protons, electrons, and neutrons. To designate an element, say thorium, the physicist employs this method:

$${}_{90}Th^{232}_{142}$$



Robert Franson

Schematic representation of the formation of a Helium atom.

The number 90 is the atomic number; the number 232 is the atomic weight; the number 142 is the number of neutrons in the nucleus of this element. The physicist has discovered that if he can split this atom, a great amount of heat is liberated.

The agent which causes this nuclear splitting or fission is the neutron. The neutron has no electric charge and it is not affected or influenced by the presence of matter. If the neutron comes within a distance of about 0.4×10^{-12} $_{cm}$ of the nucleus, it is subject to scattering or absorption. That is, the neutron may induce fission.

The fission process consists of the division of a nucleus such as $_{92}U^{235}$ into two or more heavy fragments. The first step is the absorption of a neutron:

$$n + U^{235} \rightarrow U^{236}$$

After emission of a captured gamma ray, the resultant U^{236} may fission into lighter elements. A typical example of such a fission is:

$$U^{236} \rightarrow {}_{56}Ba^{139} + {}_{36}Kr^{94} + 3n + \text{energy}.$$

These fragments produced have two important properties, kinetic energy and radioactivity. They are highly unstable and decay radioactively by a chain of beta and gamma ray emissions. Thus, in the production of power by fission, radioactive waste disposal becomes a problem, far greater than the problem of ash disposal in the chemical fusion reactor. Added to this there is always the danger of an accident releasing great amounts of dangerous radioactivity.

Is fission natural? Does nature behave in this manner? How does the sun produce it's enormous heat energy? In trying to answer these questions we come to the conclusion that fission is a freak, uncommon in nature, requiring very special conditions for its occurrence.

Fusion Is Ultimate Answer

Thus to meet our tremendous energy requirements of the future we must resort to fusion. But fusion of nuclei, unlike fusion of atoms, presents great problems. The most simple element is hydrogen. It is a proton with an orbital electron. The proton is positively charged and of mass one. The electron is negatively charged and of mass 1/1836. This atom is capable of undergoing beta-decay. Under such action the hydrogen atom becomes a neutron. If the neutron comes within a distance of $.4 \times 10^{-12}$$_{cm.}$ of the hydrogen nucleus is it absorbed by the proton and the result is deuterium, according to:

$$H + n \rightarrow D$$

Thus deuterium is an atom consisting of a proton, neutron and an orbital electron. It is a legitimate atom and should be included in period one of the chemical periodic table.

The next element consists of a proton and two neutrons with an orbital electron; it is of mass three and is known as tritium.

$$D + n \rightarrow T$$

This again is a legitimate element and should enter the periodic table. The next element is composed of hydrogen and deuterium, HD. It is of mass three and has two orbital electrons.

When nature fuses deuterium with deuterium, the result is D_2, according to:

$$D + D \rightarrow D_2$$

This is exactly what goes on in the sun—nature's fusion reactor.

The physicist as yet has not devised a language for his nuclei. He represents helium as $_2He^4$. We say that Helium is the result of fusion of deuterium. Helium in turn will fuse with Deuterium to form Lithium, D_3. Other deuterium fusion reactions are:

$D_2 + T \rightarrow D_2T$ an isotope of lithium
$D_2 + D_2 + D_2 \rightarrow D_6$ carbon
$D_6 + D \rightarrow D_7$ nitrogen
$D_7 + D \rightarrow D_8$ oxygen ($_8O^{16}$)
and water $H_2 + D_8 \rightarrow H_2D_8$

The fact that deuterium was found in water merely indicates that some of it has not yet fused with hydrogen.

(Continued on Page 42)

ABOUT THE AUTHOR

Mr. Yasha Yavitch received his mechanical engineering degree from Cornell in 1928. Upon graduation he accepted a position with Westinghouse but returned in 1931 to study for a MME which he received in 1933. Since then he has worked for a number of firms including General Electric, RCA and at present Northrop Aviation where he is a senior engineer. In 1950 he worked on an A.E.C. project, Fernald Area, Ohio. He is a member of the National Society of Professional Engineers, the Society of Military Engineers and the Association of University Professors.

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53. Melton, Harry C.; 54. Walker, Ewing S.; 55. Ralston, Douglas E.; 56. Patterson, Albert A.; 57. Nostrand, J. W.; 58. Mackay, Donald M.; 59. Allport, Walter F.; 60. Gold, William R.; 61. Weinberg, Langston; 62. Papenfus, Smott M.; 63. Miles, Stephen V.; 64. Carpenter, William S.; 65. Silver, Leonard R.; 66. Griffing, Brandt M.; 67. Mace, Martin T.; 68. Kreuttner, John M.; 69. Whitney, George C.; 70. Nixon, Clyde G.; 71. Austin, Theodore C.; 72. Korn, Michael G.; 73. Dake, William P.; 74. Lewis, Scott C.; 75. Gundel, Walter D.; 76. Staley, Robert W.; 77. Love, Douglas A.; 78. Tregurtha, Paul R.; 79. Abrams, Harold M.; 80. Goodman, Henry A.; 81. Abrams, David; 82. Maclay, John C.; 83. Keller, R. Davidson Jr.; 84. Knapp, J. Edward; 85. Slater, Edward; 86. Biddulph, R. B.; 87. Klein, E. Robert; 88. Saks, Gerald D.; 89. Snyder, Bernard J.; 90. Gladstone, Paul M.; 91. Todreas, Neil E.; 92. McLean, Ephraim R. III; 93. Arnaud Donald M.; 94. Welsh, Robert L.; 95. Fersing, Jan E.; 96. Shamburger, Howard M.; 97. Broadhead, James L.; 98. Link, George; 99. Loeser, David R.; 100. Laden, Steven; 101. Schabacker, James M.; 102. Paetow, Herman E.; 103. Moeller, Richard S.; 104. Moser, Philip B.; 105. Feledy, Charles F. Jr.; 106. Crimi, Peter; 107. Sherwood, Roger M.; 108. Schneider, N. F. Jr.; 109. Welch, Perry S.; 110. Rose, Vincent H.; 111. Moore, Daniel W.; 112. Rothmann, Charles P.; 113. Siegel, Mrs. Carole B.; 114. Mohler, JoAnn E.; 115. Fichtl, Ronald; 116. Andrews, Thomas M.; 117. Aron, Peter A.

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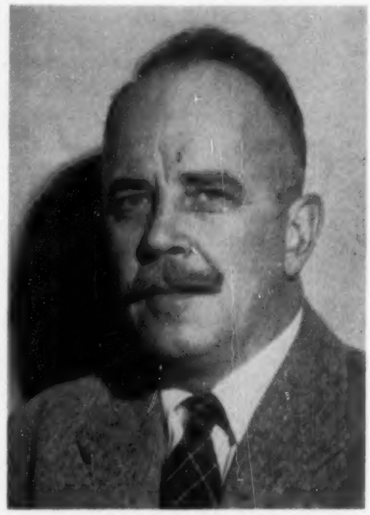


Roscoe H. Fuller

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S MESSAGE—

MEN STILL WANTED

Several months ago in this space I had a few words to say under the heading, "Men Wanted". Those words constituted a plea for greater participation on the part of you who read this page in the general area of community affairs. That need still exists, and will become increasingly urgent as the complexity of our lives increases. I trust I may be forgiven for calling it again to your attention. I am reminded of it at this time of year especially, when your Society is in the process of organizing itself for the coming year's activity.

Volunteers are wanted to assist in operating the affairs of the Society. If you are willing to assist, to give us the benefit of your suggestions, to take any sort of active part, let me know. Good men are always welcome, and there are never enough to carry out all the projects we should like to accomplish.

There is another level where good men are constantly being sought. Regardless of what you have heard about the difficulty of getting into college nowadays, well-qualified applicants are still wanted. That statement may need some amplification. It has been the custom for a number of years for secondary school students to apply to several colleges for admission in order to be sure of getting at least one acceptance. The most desirable applicants are most apt to be accepted wherever they apply, with the result that they find themselves with a considerable freedom of choice by the time the end of secondary school approaches.

The Engineering College at Cornell is perhaps especially fortunate in comparison with other institutions in the matter of selection of and by these highly-qualified applicants. Nevertheless, there are every year a number of students who have been accepted at Cornell who choose to go elsewhere. In any given case, Cornell may be a second or third choice; there may be a family tradition centered on another school, or the traditions and manifold advantages of a Cornell education may not have been put before the applicant with sufficient emphasis.

The annual "Cornell Day" in the spring, when a number of juniors from high schools all over the country are brought to Ithaca for indoctrination is an attempt in the direction of solving this problem, and it has been highly successful. Secondary schools chairmen of the various local Cornell Clubs have supplemented these efforts to good effect.

For the past several years this Society has invited a number of accepted candidates to its annual meeting to meet Dean Hollister and to learn from him about Engineering at Cornell. Of those attending these meetings, the proportion actually entering Cornell has run consistently a third to a half higher than the usual proportion of accepted applicants who actually appear for registration.

This year, similar steps have been taken by the local branches of the Society in Boston and Philadelphia, and it is fully expected that the results will be equally good. We expect to expand this activity in future years.

There is still work to be done on this project, and you can help. Not every worthy applicant lives near enough to be invited to an annual meeting. Few can avail themselves of the opportunity offered by "Cornell Day". Still fewer find it possible to travel to Ithaca on their own, to see for themselves what the place is like and what it has to offer.

If you are willing to spend a little time with the boys in your area who may be considering Cornell and with their parents, answering questions, explaining the Cornell tradition and telling them of the opportunities we have to offer, you would be helping your College and your University. If you can get together a group of Engineering alumni who are willing to organize a more formal presentation it may be possible to obtain a speaker from Ithaca to help the cause along. You may count on the officers of your Society to help in any way they can.

Men are still wanted. Good men. You can help get them for us, and in so doing, help Cornell.

ROSCOE H. FULLER

ALUMNI ENGINEERS

Peter Antonelli, ME '19, is in La Paz, Bolivia, to act as project manager and consultant to the Bolivian mining industry and to evaluate investment opportunities there. Since graduation, Mr. Antonelli has worked continuously for Ford, Bacon, and Davis, Engineers. His work has involved large scale engineering surveys, economic studies, and construction of industrial plants, oil properties, and light and power plants. He has also worked on mining, sugar, water supply, and natural gas projects both in the United States and in foreign countries.

Lawrence S. Waterbury, CE '19, is a recognized authority on the subject of highways. He has a background of many years of engineering experience in this field. Recently, he was one of twelve experts to be asked by the Engineering News Record to express an opinion on the subject, "Should the Federal Government reimburse states and toll authorities for roads on the interstate system already built to required standards?"

Robert H. Bahney, ME '17, has retired as chief engineer at Republic Steel Corporation. Mr. Bahney had been with Republic Steel for his entire business career of forty years.

John Mitchell, ME '48, is now assistant to the president of Milton Roy Company of Philadelphia, manufacturers of controlled volume pumps and chemical feed systems.

John Mitchell

Albert E. Frosh

Albert E. Frosh, CE '10, has retired after forty-six years as an engineer and government employee. He has been connected with the Ordnance Ammunition Command and Joliet Arsenal since 1940. From 1940 till 1945, he was chief engineer for Sanderson and Porter, contractors who designed, built, and operated Elwood Ordnance Plant, now the Elwood Unit of Joliet Arsenal. Since 1947, he has held top posts at the OAC and its predecessor organizations at the Joliet ammunition headquarters. For several years he has been the principal negotiator for all OAC contracts and special assistant to the OAC commander. Friends at the OAC held a testimonial dinner for him January 4.

Creed W. Fulton, ME '09, has become vice-president in charge of the Philadelphia district of The Work-Factor Co., management consultants and industrial engineers. The company has developed precise time-study standards for industrial production and offers consulting and management services for business and industry.

John Dickey Lincoln, ME '24, is now with the Mount Vernon, Ohio, division of Continental Can Company. He is presently active in the development of a new product for the company made of plastic and fibre glass combinations which will combine great strength with light weight.

George S. Goodwin, ME '99, is now an inspector with R. W. Hunt Engineers and lives in Chicago, Ill. In 1944, at the age of sixty-seven, he retired from the Rock Island Railroad after 38 years of service, where he had been assistant to the general superintendent of motive power. Soon afterwards he joined the newly-formed railway supply division of Reynolds Metal Co. and became assistant manager. In 1946 he joined the Transportation Research and Development Command of the Transportation Corps of the US Army. For ten years he was a project engineer, first in Brooklyn and later at Ft. Eustis, Virginia.

Charles W. Egbert, ME '36, has been named manager of applications for York Corporation, a subsidiary of Borg-Warner. Mr. Egbert joined York Corporation in 1936 and has held a number of sales and engineering positions in the organization since then.

Harold M. St. John Jr., ME '42, has been appointed as assistant general manager of the recently-formed Sundstrand Turbo Division of the Sundstrand Machine Tool Company, Rockford, Illinois. St. John was formerly manager of sales at Sundstrand-Denver, which he joined in 1956. He spent fourteen years with United Aircraft, Hamilton Standard Division, in Windsor Locks, Connecticut as a flight test engineer, systems engineer, and preliminary design engineer for control systems for turboprop and turbo-jet engines.

At Cornell St. John was a member of Tau Beta Pi, honorary engineering society, and Phi Kappa Phi, honorary educational fraternity, and rowed with the Big Red crew. He is a member of the Institute of Aeronautical Sciences and American Rocket Society.

G. Gordon Brode, CE '34, is now a national director of Associated General Contractors of America. He just completed a year as president of the Ohio Contractors Association. He is also vice-president of W. M. Brode Co., railroad and highway contractors.

(Continued on Page 39)

FIFTY YEARS AGO IN THE ENGINEER

The White Steamer was awarded first prize in the "dust competition" recently held in England at the new Brooklands Race track, under the auspices of the Royal Automobile Club. The most careful preparations were made for this competition in order that the results might be authoritative and unquestioned. A 100 ft. section of the track was covered with a layer of powdered chalk and, after each car had made its trial, the track was restored to its original condition. By means of an ingenious mechanical pacing device, each car maintained a uniform speed of 20 miles an hour. By means of an electrical device, a photograph was taken of each car at precisely the same point and the resulting photographs were studied at leisure by the Committee.

The result of this contest officially confirms the general opinion that the White Steamer raises less dust than any other car.

—Advertisement, October 1907

The report of President Schurman to the Board of Trustees of Cornell University, which has just been issued, shows that for the year ending September, 1907, the total number of regularly enrolled students was 3523. Of this number 82 were studying architecture, 466 civil engineering and 1081 mechanical and electrical engineering. . . . Hitherto students upon graduation at the high schools have been admitted to the Cornell courses in law, medicine, civil, mechanical, and electrical engineering, and on completion of their professional courses have received the professional degrees. President Schurman's recommendation is that in the near future matriculants at Cornell University shall spend one or more years in the study of language, literature, history, economics, political science, etc., before admission to any professional courses of the University. . . .

—November 1907

The new five year course leading to the degree of Mechanical Engineer, which is to be offered to the entering class for the first time next Fall, is a step in the right direction in which Cornell has taken the lead. Coming as the announcement does, almost at the same time as the change to the higher standard required for entrance to the Cornell Medical College, it emphasizes the spirit of broad-mindedness and culture which it is the desire of President Schurman shall characterize the Cornell graduate. . . . It will be interesting to note how the students choosing this new course compare in number with those entering the regulation four year course. Should the comparison prove favorable to the new scheme, it is hard to estimate what the effect will be upon the curriculum of the various engineering schools throughout the country; for it is quite likely that after the initial step has been taken, others will not be slow to follow in the steps of Cornell, as she leads on to better things.*—January 1908*

Soon after the great work of the first year of the reign of the present Emperor of Japan (1867), the new government directed serious attention to the subject of education, both common and special, and several new schools and institutes were established. The College of Engineering of the Tokyo Imperial University had also been originated at that time. . . . The fees to be paid to the university by the student are of very small amount, because most part of the running expenses of the University is supplied by the government. . . . *—June 1909*

The development of our system of general education is the great work of our day and generation. The wisdom and foresight of our statesmen as well as of our educators is to be tested, is to be measured by the promptness and effectiveness with which they adapt their own ideas, and fit the educational to the requirements of a modern industrial organization. . . . At the moment, what is more needed is the awakening of our legislative and executive officials to the duties and opportunities of the times. It is the fossilized educator and the ignorant and unpatriotic politician, and the demagogue who aspires to lead "labor," and the scientific man with his head in the clouds who are most dangerous as obstacles to the progress of education, of our industries and of the nation, toward higher and better things. These classes being either educated and purified, or extinguished, we may trust the American people to take full advantage of their opportunities and to hold a foremost place in the peaceful rivalry of the nations.*—Quotation of Prof. Rob. H. Thurston, November 1903*

(Continued on Page 42)

M.E.'s MOVE TO UPSON HALL

The Sibley School of Mechanical Engineering, after many years of association with Sibley Hall, has moved to its new residence in modern, spacious Upson Hall. The operation was completed during spring vacation and all staff offices and equipment belonging to the departments of industrial engineering, freshman drawing, machine design, and thermal engineering were transferred to their new quarters.

Construction on Upson, a gift of Maxwell M. Upson '99, was begun in the latter part of the fall of 1956, and is now fully completed with the exception of landscaping and the relocation of some equipment.

The Sibley School of Mechanical Engineering dates from 1870 when a series of donations from Hiram Sibley resulted in the erection of what is now West Sibley. East Sibley and Sibley Dome were erected in 1894 and 1901 respectively from donations by Hiram W. Sibley. Plans for the present engineering quadrangle began to develop in 1937 under Dean S. C. Hollister and construction of Upson became the realization of a twenty year's ambition.

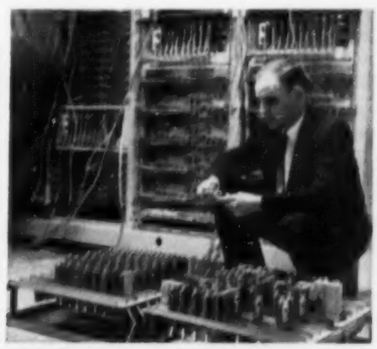
Sibley Hall will be occupied by the College of Architecture, which has been holding several classes there this past term. After some minor alterations, such as the relocation of the Architecture Library and the refurbishing of Sibley Dome, the College expects to utilize the building completely. East and West mechanical labs, located behind Sibley, will be used until the end of the spring term, when they will either be razed or used as studios for the architecture college.

Upson Hall has three wings, the north-south wing parallel to Phillips Hall and devoted to laboratories, the west wing next to Kimball Hall, providing classroom and administration facilities, and the east wing housing the Graduate School of Aeronautical Engineering. The building is the largest on the new engineering quad and includes several large labs located in the basement and over fifty recitation rooms. The new labs include the engine lab, water flow measuring lab, cold and warm room labs, and the two-story thermo lab. These labs will provide facilities for work with internal combustion engines, turbo generators, temperature investigations, instrumentation and control, combustion research, engine component studies, methods and production engineering, gas turbines, and solar radiation and air flow studies. A large portion of the open laboratory floor space will be devoted to graduate research and fifth-year projects. The building also includes a large lecture room and a student lounge.

The aeronautical wing will have three levels with the first floor devoted entirely to laboratory work and including a two story wind tunnel. The second level will include eight smaller laboratories and several darkrooms. All offices and classrooms will be on the third floor.—*by L. A. Wheeler, ChemE '62*

Photographs by N. F. Brockmeier

This Thermodynamics class was one of the first to use the large and well-lighted classrooms of the new Upson Hall.



COLLEGE NEWS

AERO ENGINEERING BUILDING DONATED BY LEROY GRUMMAN

Leroy R. Grumman, founder and chairman of the board of Grumman Aircraft Engineering Corporation of Bethpage, L.I., has made a gift of $500,000 to Cornell University, it was announced by Deane W. Malott, Cornell president. The fund will be used for a new building for the Graduate School of Aeronautical Engineering, which is now in the initial stages of construction, and which will provide exceptional facilities for study and research in aeronautical science and technology.

Mr. Grumman, who received his degree in mechanical engineering at Cornell in 1916, is a Trustee of the University. The gift for this building is the most recent of a number of gifts he has made to Cornell.

The new structure will be three stories high, of reinforced concrete, and will provide facilities for advanced work in aeronautical engineering. There will be a wind tunnel on the ground and second floors which will be designed for low-speed investigations of turbulent flow and boundary layers; a machine shop equipped with specialized tools required for construction of precision research equipment, and a machinery room with space for air compressors, wind tunnel power supply and storage of gases required in research laboratories; all on the first floor.

On the second floor a gasdynamics laboratory will provide facilities for study of high speed flow problems of the type encountered in the design of aircraft and missiles, and an aerodynamics laboratory equipped for fundamental studies in aerodynamics and for investigations of wing and compressor blades.

Adjoining these laboratories on the second floor will be an electronics room where specialized instrumentation for aerodynamics and gasdynamics will be built.

The top floor will be given over to departmental and staff offices, classrooms and conference room.

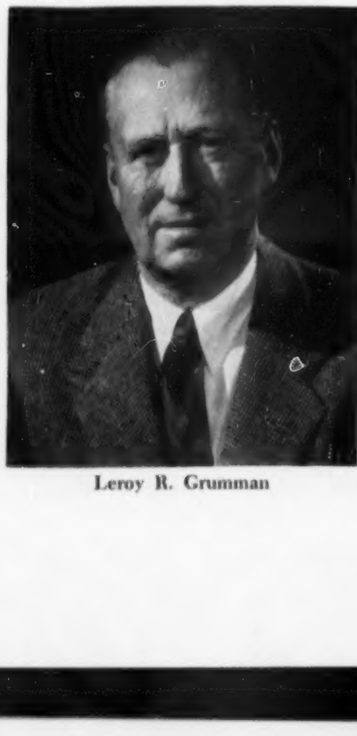
The exterior of the new building will have facings of native stone and limestone, and terra cotta spandrels of blue-green to harmonize with nearby Phillips Hall for Electrical Engineering and other structures in the quadrangle. Construction of the building started last fall, and is scheduled for completion later this year.

It will be connected to Upson Hall for Mechanical Engineering, making possible joint activity by aeronautical and mechanical engineering on many advanced problems in these fields.

In accepting the gift, President Malott said: "Mr. Grumman's generosity to Cornell is not only an expression of his continuing loyalty to Cornell, for which we are deeply grateful, but also of his desire that young men who are entering aeronautical engineering be provided with the best facilities for study and for research. He has been—and is—a pioneer in aeronautical engineering, and he is giving valiant aid in the task of educating tomorrow's pioneers."

Mr. Grumman is a former member of the Cornell Aeronautical Laboratory Industrial Advisory Board, and at present is a member of the Cornell University Council as well as of the Board of Trustees.

A naval aviator in World War I, he served in various posts as aviation engineer and test pilot until 1920 when he joined an aeronautical engineering firm in New York.



Leroy R. Grumman

Ten years later he organized his own company, Grumman Aircraft Engineering Corporation. During World War II the company employed more than 25,000 persons and broke production records in supplying the U.S. and allied navies with aircraft.

At the end of the war he was awarded the Presidential Medal for Merit, highest civilian citation. In 1948 he was given the Daniel Guggenheim Medal, and in 1952 he was elected American Honorary Fellow of the Institute of Aeronautical Sciences.

SATELLITE TALK GIVEN BY DR. JOHN P. HAGEN

Describing the purpose of the Navy's recently launched satellite, Dr. John P. Hagen, director of Operation Vanguard said, "The satellite serves as a platform that carries scientific instruments which record and transmit information. It is more of a tool than an experiment." Dr. Hagen spoke before an audience of 1700 people at Bailey Hall on March 27.

Dr. Hagen told about the problems encountered when the task of putting a satellite up was assigned to him. Sufficient potential energy would be needed to lift the satellite 200-300 miles above the earth and a velocity of five miles per second would have to be attained in order for the satellite to maintain its orbit. A rocket, in this case, the Vanguard, was chosen as the vehicle for carrying the satellite.

The Vanguard is a three-stage rocket. Dr. Hagen explained, with the aid of slides, the function of each stage. The first stage, which employs liquid oxygen, kerosene, and helium as fuels, is propelled to a height of 40 miles by a 27,000 pound thrust rocket engine. The first stage drops off as the second stage programs the satellite to a velocity equal to one half that required for orbiting, and a height of 140 miles. After a five or six minute coasting period, which brings the rocket parallel to the earth, the third stage shoots the satellite into orbit at the required velocity of 18,000 miles per hour.

Dr. John P. Hagen, Director of the Navy's Vanguard Rocket Program, addresses a near-capacity audience in Bailey Hall.

The satellite, which is tracked by the Navy's minitrack along the 75th meridian and by the Smithsonian Astrophysical Observatory in Cambridge, is currently transmitting much valuable information about the galaxy, according to Hagen. It is recording pressure, density, and meteor and cosmic ray information of the upper atmosphere. Advances in meteorology are being made because the satellite can send back a picture of the cloud cover, and the radiation input and output of the earth.

The satellite, itself, is 20 inches in diameter and weighs 21½ pounds. The instruments are in the center of the highly polished aluminum sphere. Protruding from the sphere are the satellite's six antennae.

Hagen concluded his talk by showing movies of the successful launching of a satellite on March 17. He said, "The compulsion behind this work is the desire of man to increase his knowledge of the universe. The work, which required tremendous effort, wouldn't have been done without this high aim. The greater knowledge will make our living much better than it is."

In a question and answer period after his talk, Dr. Hagen commented on the differences between the satellite of the U.S.S.R. and that of the United States. He said Russia's satellites are certainly superior from a military standpoint, but it will be six to eight months before we will be able to tell if the Sputniks gathered more information than that of the United States sphere.

ENDOWMENT FUND FOR BOOKS ESTABLISHED BY CARPENTER

An endowment of $250,000 for the new engineering library at Cornell University has been established by Walter S. Carpenter, Jr., chairman of the board and former president of E. I. du Pont de Nemours and Company.

Income from the endowment will supplement existing funds for the purchase of books, microfilm texts of important scientific works, professional magazines and other literature.

The engineering library is located in Carpenter Hall which also will house the administrative center of the new engineering quadrangle nearing completion on the Cornell campus. Carpenter Hall was given to Cornell last year by Mr. Carpenter.

Acknowledging the gift, President Deane W. Malott described it as "another expression of Mr. Carpenter's concern with the state of higher education in science and with the future growth of Cornell as a center for the training of potential leaders in the engineering profession."

GRANTS RECEIVED FROM AEC FOR NUCLEAR PROGRAMS

The Atomic Energy Commission, which has instituted a program that provides funds to educational institutions for training programs, has made a grant of $58,365 to Cornell University, it was announced. The grant, which was received in January, was the second such award to Cornell. The first, in the form of uranium for a subcritical reactor, was received in December, 1956.

Cornell, through Professor James Aregy, requested funds to be used for equipment for the course EP 8351 and also for the Metallurgical Department of the University. EP 8351, to which approximately $39,000 was allotted is a nuclear lab course taken in the fifth year or in graduate work. This money will be used for electronic apparatus and for the construction of a graphite neutron source. The balance of the grant went to the Metallurgical Department where it will be used for an investigation into the casting and examination of uranium equipment.

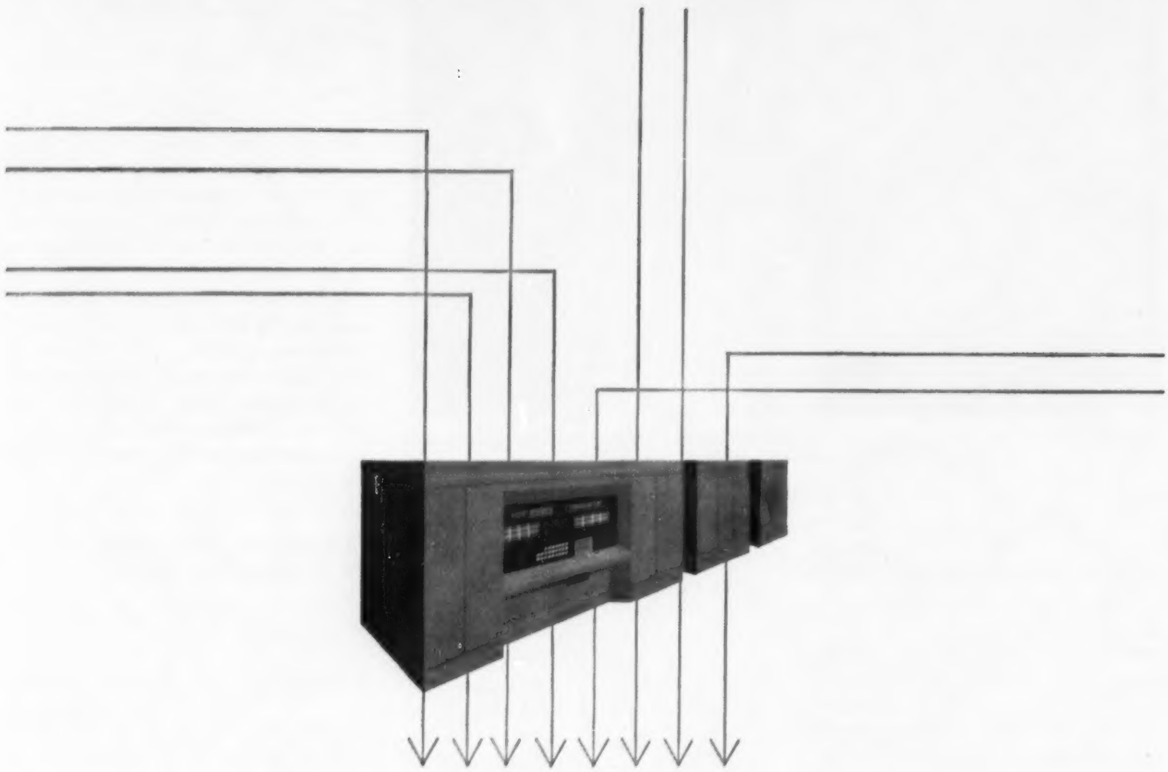
CORNELL TO PARTICIPATE IN EDUCATIONAL GRANT

Cornell University is expected to participate in the $100,000 educational grant from Wheelabrator Foundation to the Foundry Educational Foundation it was announced Wednesday, March 12, at the F.E.F. College-Industry Conference in Cleveland, Ohio. The bulk of the grant is accounted for by 50 fellowships of $1,500 each.

The grants for graduate study are intended to foster and improve education in foundry science, engineering and operation. Cornell University is one of 17 schools throughout the country that are designated as F.E.F. schools. It receives scholarship support from the F.E.F. and works in cooperation with the Foundry Educational Foundation to strengthen foundry education at the collegiate level.

Malcolm S. Burton, Professor of Metallurgical Engineering, is the F.E.F. key professor at Cornell University and is the primary contact at the University for F.E.F. activities.

Both F.E.F. and Wheelabrator spokesmen expressed the hope that the new program would have impact not only in the foundry industry but also in other industries, companies and associations. They stressed the need for advanced science and engineering on every front and pointed out the very substantial support of education that would result if every company in every industry were to contribute according to its means and ability.



ALUMNI NEWS

(Continued from Page 31)

Albert J. Blackwood, ME '24, has been selected as one of the ten technical leaders in the oil industry named to the U.S. committee of the Fifth World Petroleum Congress to be held in New York City in June, 1959. The purpose of this Congress is to exchange technical information relative to oil and allied industries. Mr. Blackwood's responsibility will concern papers on the utilization of oil products. Mr. Blackwood is associate director of the products research division of Esso Research & Engineering Co. He has been with the firm more than thirty years. Following his graduation from Cornell, he taught experimental engineering for three years at the university.

Thomas A. Bissell, ME '22, has been appointed executive secretary of the Society of Plastics Engineers, with headquarters at Greenwich, Conn. Formerly, Mr. Bissell had been with the Society of Automotive Engineers, first as the technical editor of their journal and later as manager of the meetings division.

Peter Antonelli, ME '19, is in La Paz, Bolivia, as project manager and consultant to the entire Bolivian mining industry and evaluating investment opportunities. Since graduation, Antonelli has been continuously with Ford, Bacon and Davis, Inc., engineers of New York City. His work has involved large scale engineering surveys, economic studies, construction of industrial plants, oil properties, light and power plants, mining, sugar, water supply, and natural gas projects, both in the United States and foreign countries.

F. Donald Hart, ME '36, has been elected president of Temco, Inc., of Nashville, Tennessee, nationally known manufacturers of air conditioning equipment and water heaters. He had formerly served for nearly ten years as executive vice-president of the company. Mr. Hart is also active as an officer in a number of industry associations and is currently chairman of the Chamber of Commerce's "Greater Nashville Committee."

THE CORNELL ENGINEER IN THE NEWS

THREE MEMBERS RETIRE FROM THE CORNELL ENGINEER STAFF

The March Issue marked the last for three members of the CORNELL ENGINEER staff. These people have contributed much to the success of the magazine over the past few years.

Dick Brandenburg, editor-in-chief, is completing his fifth year working for the ENGINEER. Starting out as a member of the editorial board, he subsequently held positions as assistant editor and managing editor.

Dick, who was married last December, has found time to participate in many other activities besides the ENGINEER. He has been very active in CURW as president of the New York State Student Methodist Movement, treasurer and program chairman of the Wesley Foundation and chairman of the religious Calender Committee. Dick has also held several offices in his fraternity, Phi Kappa Tau.

As a tribute to his highly successful career at Cornell, Dick, a mechanical engineer, has been elected to several honorary societies. These include Tau Beta Pi, Pi Tau Sigma, Sigma Delta Chi, Pi Delta Epsilon, Phi Kappa Phi, and Quill and Dagger.

Next year, Dick intends to do graduate work in business administration with the aim of a career in the aviation industry.

Dave Koppes started working on the ENGINEER four years ago as a Freshman. Among the positions he has since held are circulation manager, illustrations editor, and during this past year, business manager.

Dave has had an interest in many other activities as evidenced by the number of offices he has held. He has been president of Delta Phi fraternity, treasurer of Chi Epsilon, which is the civil engineering honorary society, president of Rod and Bob, and secretary of the Civil Engineering Honor Committee. He has also been elected to Scabbard and Blade and Pi Delta Epsilon. Another of Dave's interests is flying for which he has a pilot's license.

Tentatively, Dave is planning for a career in structural or highway design.

Interested in working on magazines, Barbara Jo Merkens, or "BJ" as she is better known, decided to compete for the ENGINEER two years ago. This year, she served as office manager.

Presently, BJ is serving as a VPR in Dickson Hall. She is also a member of the Wesley Foundation in the CURW and has been elected to two honorary societies, Pi Delta Epsilon and Kappa Delta Epsilon.

BJ, a senior in the Arts School, is majoring in history. After graduation, she hopes to teach history in secondary school.

MALOTT GIVES TALK AT ANNUAL ENGINEER BANQUET

On Sunday evening, April 13, the annual banquet for the staff and guests of the CORNELL ENGINEER was held at the Ithaca Hotel. After a delicious roast beef dinner, Dick Brandenburg, retiring editor-in-chief and toastmaster for the evening, reviewed the year's accomplishments and outstanding achievements. In particular, he mentioned the move to the new office in Carpenter Hall and the three special issues published during the year. Gifts to the outstanding compets on each board were presented to Larry Wheeler, Larry Rosenthal, and Robert Franson.

The guest speaker for the evening was President Deane W. Malott, whose talk, "A University is Not a Railroad," explained the relationship between the business world and the university world. He enumerated the various complexities of running a university like Cornell and the problems faced in financing its operations. He also stressed the need for cooperation between universities and business and between universities themselves.

FIFTY YEARS AGO

(Continued from Page 33)

Coal washing was first developed in Germany, and not until 1870 was a washer built in this country. From 1869-1873 several washers of about 100 tons capacity each were constructed, one near Pittsburgh, two in St. Louis and several through the various coal regions. During the panic of 1873 the iron industries were most seriously affected, and it was not until 1879 that business conditions warranted the erection of other washeries. Since then a variety of improvements have been made in washing plants and at the present time there are a large number of washeries scattered all through the coal regions; the increasing demand for satisfactory coke, having made it necessary to open coal fields heretofore considered too poor to be profitable as coking propositions. This activity in coal washing and in inventing improved methods is greatly needed as there is at the present time no satisfactory, efficient, and scientifically constructed apparatus on the market to handle low grade coals.—The Sibley Journal of Engineering, *April 1908*.

The comparison made of the steam turbine and reciprocating engines is one that is well understood and is used to illustrate in a way the reason for the present trend of the times in machine design which indicates unerringly a movement from the reciprocating toward the rotary type of machine, whether this be turbine, motor, blower or pump. Until quite recently the rotary pump—the direct solution of the pumping problem—was not considered practical where high pressure and efficiency was required. This made the reciprocating pump with its heavy and expensive gearing and accompanying noise, vibration, and great liability to break down a necessity. The past five years, however, has witnessed a great change in the design of pumping machinery, and at present the centrifugal and turbine pumps in which there is but one moving part, the impeller, occupies a relatively more important position in this field than the steam turbine does in the field of prime movers.—The Sibley Journal of Engineering, *April 1908*.

ENERGY AND THE ELEMENTS

(Continued from Page 21)

From these equations one can conclude that any element is a macroscopic system of deuteriums and that any isotope is a macroscopic system of deuterium and tritium. The presence of tritium then is an indication of instability of the nucleus.

At present the physicist represents any element as ${}_{Z}X_{N}^{A}$ where:

X stands for the element,

Z stands for the number of electrons or the atomic number,

A stands for the atomic weight,

N stands for the number of neutrons in the nucleus.

But one may ask the physicist this question. How are the neutrons distributed in an element? Are they in a bundle in the K shell? Are they free to roam?

The answer is that the neutrons are attached to the hydrogen atom in the form of deuterium or tritium.

Thus any element may be represented by:

D_xT_y

$x+y=$ atomic number.

$2x+3y=$ atomic weight.

Let us take curium atomic number 96 and atomic weight 242. It is D_xT_y.

$$x+y=96$$
$$2(96-y)+3y=242$$
$$y=242-2\times96=50$$
$$x=96-50=46$$

Curium is $D_{46}T_{50}$.

The fact that the curium nucleus contains fifty tritiums or tritons, makes it vulnerable to beta-decay.

$$T_2 \xrightarrow{-\beta^-} D_3$$

It may become an element of the form $D_x = 3\ T_{y-2}$.

$D_{46}T_{50} \xrightarrow{-\beta^-} D_{49}T_{48}$ (berkelium)

The Nuclear Periodic Table

Thus we must draw the inevitable conclusion: elements are a result of fusion with deuterium and tritium as building blocks.

Figure one is an attempt to build a physical picture of the method nature uses to build the elements. It should serve only to help mental curiosity.

We do not make any attempt to explain the processes involved in this fusion. They are complicated and do not belong in the scope of this treatise. Our future power, however, must come through nuclear fusion. The problem of nuclear fusion will certainly be solved eventually by scientists and engineers. But in order to approach this solution of using water as a fuel, we must devise a language for nuclear physics. In petroleum it is necessary to know that a molecule is of the form C_nH_{2n+2} or C_nH_n to scientifically and efficiently burn it in the combustion chamber of the piston engine, turbine or in the furnace of a boiler. In the same manner, if we are to abandon chemical fusion in favor of nuclear fusion for the production of power, we must learn an efficient system of nomenclature for the nuclei of atoms. With that aim in view a Nuclear Periodic Table has been devised by this author. This will be the first time it has ever appeared in print.

From the equations discussed above, we may a priori predict that it is possible to discover 121 elements. The last element would consist of D_{121}.

This author would honor his Alma Mater by naming the 115th element Cornellium ($D_{103}T_{12}$).

Element	At. No.	Atomic Weight	Nuclear Symbol	Chem. Symbol
Hydrogen	1	1.008	H	H
Deuterium	1	2.017	D	
Tritium	1	3.026	T	
			HD	
Helium	2	4	D_2	He
Lithium	3	6	D_3	Li
Lithium	3	7	D_2T_1	Li
Berilium	4	9	D_3T_1	Be

Portion of proposed nuclear periodic table, all elements are made up of the building block DEUTERIUM—D. Elements with an oversupply of neutrons, isotopes, are built up of DEUTERIUMS + TRITIUMS.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CERTIFICATE OF MEMBERSHIP

TECHNIBRIEFS

ALUMINUM RUST FILMS USED IN ELECTRONIC TUBES

Scientists at the Westinghouse Research Laboratories are using aluminum foil—household variety—in delicate scientific experiments and in the construction of experimental electronic tubes.

However, the scientists do not employ the complete foil—itself only about one-thousandth of an inch in thickness. Instead, they discard about 99.9 percent of it by chemically dissolving away all the aluminum metal and saving the thin aluminum "rust" or oxide which coats the foil to a depth of less than a millionth of an inch.

The film of aluminum oxide is used to support the layers of sensitive material required in electronic imaging tubes. Because of its extreme thinness, electrons traveling through the tube can penetrate the sensitive layers without being interrupted by a supporting structure. To work at all, it must be extremely thin, but it must also be large enough to serve as a miniature screen within the tube. While the films themselves have been known for several years, only recently have they been made thin enough and large enough to be practical.

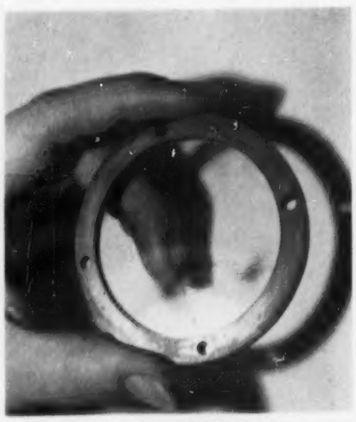
In spite of their delicacy and exactness, the ultrathin films are prepared by simple techniques which require no unusually precise apparatus.

A piece of aluminum foil, free of wrinkles, is pressed flat. The aluminum oxide coating on one surface of foil is removed by rubbing with a solution similar to common lye, exposing the aluminum metal underneath.

With the oxide on one side removed, the foil is washed in distilled water, dried, and placed in an acid solution. The acid "eats" away all the aluminum metal, leaving only the thin coating of oxide on the other side of the foil. This film is washed, dried and mounted on a round metal ring of the desired diameter.

Since the ordinary oxide coating on the surface of aluminum foil is usually too thin, it is built up before preparing the film by electrically depositing an additional oxide film of the foil in an acid solution. By controlling the voltage, a perfect coating of any desired thickness can be prepared.

The aluminum oxide films are estimated to be only from 25 to 50 molecules thick, and measurements show that a film may vary in thickness over its entire surface by not more than a single molecule. Yet even though they are so thin as to be transparent, their tensile strength is estimated to be about equal to ordinary steel.



With a thickness of only about one-twentieth of the wave length of the light rays passing through it, this film of aluminum oxide supports itself as well as the spider moving across it.

ELECTROLUMINESCENCE USED IN NEW RADAR DEVELOPMENTS

Two new advances in radar development, both utilizing the phenomenon of electroluminescence, have been announced by Sylvania and RCA.

The "Sylvatron", developed by Sylvania, produces images on flat panels and is believed to have important possibilities in development of radar, area surveillance, air traffic control systems, computers and instrumentation.

The panels utilize not only the principles of electroluminescence—the production of light by direct excitation of certain phosphors in an electric field—but also the principle of photo conductance, which is the influence of light on the flow of electricity through a solid.

A three foot by four foot "Sylvatron" panel will be employed as a plotting screen for use in fleet maneuver training by the Navy. For training problems involving the maneuvers of large fleets, ship movements would be represented on the plotting screen by lighted tracks, triggered by a moving spot of light. The image created by the light can be stored indefinitely.

The display panels described by the RCA specialists include one in which a new electronic principle is employed to achieve a light amplifier which, after a 1/100-second exposure to a dim image, stores and displays the image in bright form for several minutes or longer. Another type, employing different principles and a more complex structure, was described as combining picture detail with long image persistance.

The ability of the panel to store a bright image after only a brief exposure results from the discovery of a previously unknown phenomenon in cadmium selenide, a photoconductor material which is an insulator in darkness but becomes a conductor of electricity upon exposure to light. Under the influence of applied voltage and exposure to light, the conductivity of the cadmium selenide will increase sharply and will remain high for long periods after the light source has been cut off.

POWERFUL NEW ENERGIZER IN FLASHLIGHT CELL SIZE

A new portable power source packing the energy and high current drain characteristics of an alkaline cell into the compact space of a standard flashlight battery has been announced by National Carbon Company, Division of Union Carbide Corporation. This leak-proof alkaline cell energizer will give up to 10 times longer service than a standard flashlight cell at but approximately 3 times the cost.

Described as a significant technological breakthrough in power sources for electronic equipment,

the new cell is engineered for high-drain, continuous duty, making possible portable devices using transistors and vacuum tubes that were previously not feasible, and resulting in more efficient operation of existing portable equipment. In addition to the amount of energy available, the alkaline cell can deliver energy at a much faster rate than conventional flashlight cells.

ELECTRONIC CONTROL SYSTEM FOR VEHICLES INSTALLED

At the intersection of Nebraska Highway 2 and U.S. 77, south of Lincoln, Nebraska, an electronic system for vehicle control requiring no special equipment in motor vehicles has been established by RCA and the Nebraska department of roads.

A field demonstration of the system showed the following features:

—Operation of lights giving right-of-way at point of merging traffic;

—Warning a driver when he follows too closely behind another vehicle;

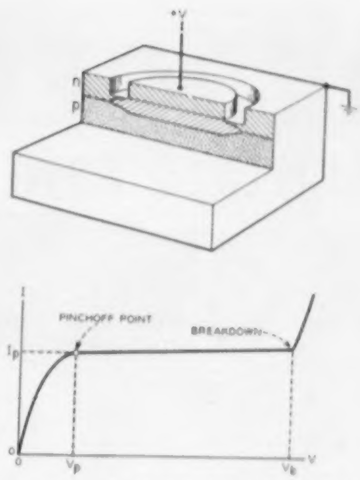
—Indicating to a driver the presence of an obstacle in the highway ahead;

—Simulating the automatic guidance of a car along its traffic lane.

It was emphasized that the present test installation represents a purely experimental step designed to study and demonstrate the principles of electronic vehicle control and evaluate certain features of the present system. It was indicated that a logical next step would be the development of a more extensive test facility, such as a complete mile or two of highway equipped with a variety of safety devices and including fully equipped test vehicles.

The system as it now stands is "compatible" in its ability to perform many important safety functions on the highways, even without the installation of special equipment in automobiles.

The electronic elements which are used in these tests, buried in the highways, can be used in their present form to activate many different arrangements of warning lights and signals placed along the right-of-way and to do many things that would contribute substantially to greater safety in driving.



Top: Cross-Sectional view of the Bell Labs' varistor. Bottom: Plot of varistor characteristics.

SEMICONDUCTOR COMPONENT GIVES CONSTANT CURRENT

A two-terminal, passive semiconductor component having novel and highly useful characteristics has been developed by Bell Telephone Laboratories.

Known as a field effect varistor this component has a constant-current feature which makes it ideally suited for a current regulator in circuits where either the load or supply voltage vary over wide limits. It can also be used as a current limiter or pulse shaper. Its a.c. impedance is very high, making it useful as a coupling choke or an a.c. switch.

The device, closely related in principle to the field effect transistor, contains a single planar junction which is made by diffusion. Current passes parallel to this junction through a constricted region called the channel. As the voltage across the device is increased, current increases and a depletion layer builds up which eventually reaches through the entire thickness of the channel. At this point, called the "pinch-off" point, a further increase in voltage does not produce any increase in current. Eventually an avalanche breakdown occurs, as the voltage is increased still further. Between the pinch-off and breakdown points, the current is essentially constant, and this is the region of maximum interest.

At present the varistors are fabricated by cutting dice from a slice of germanium or silicon containing a single diffused junction. The dice are heavily plated on all surfaces, and a circular trench is then cut into the diffused layer to within about 0.1 mil of the junction. This cutting requires a high degree of precision, since the characteristics of the final device depend heavily on the spacing between the bottom of the trench and the junction. In exploratory work, the trench is first cut with an ultrasonic tool and finished to the desired depth by etching. Leads are then attached by thermo-compression bonding or other convenient means.

Characteristics of the device can be altered by varying such parameters as channel depth, impurity gradient, length and width of channel, and selection of semiconductor material. Using silicon, units have been fabricated with a regulated current of one milliampere, pinch-off voltage of 10 volts and breakdown of 150 volts.

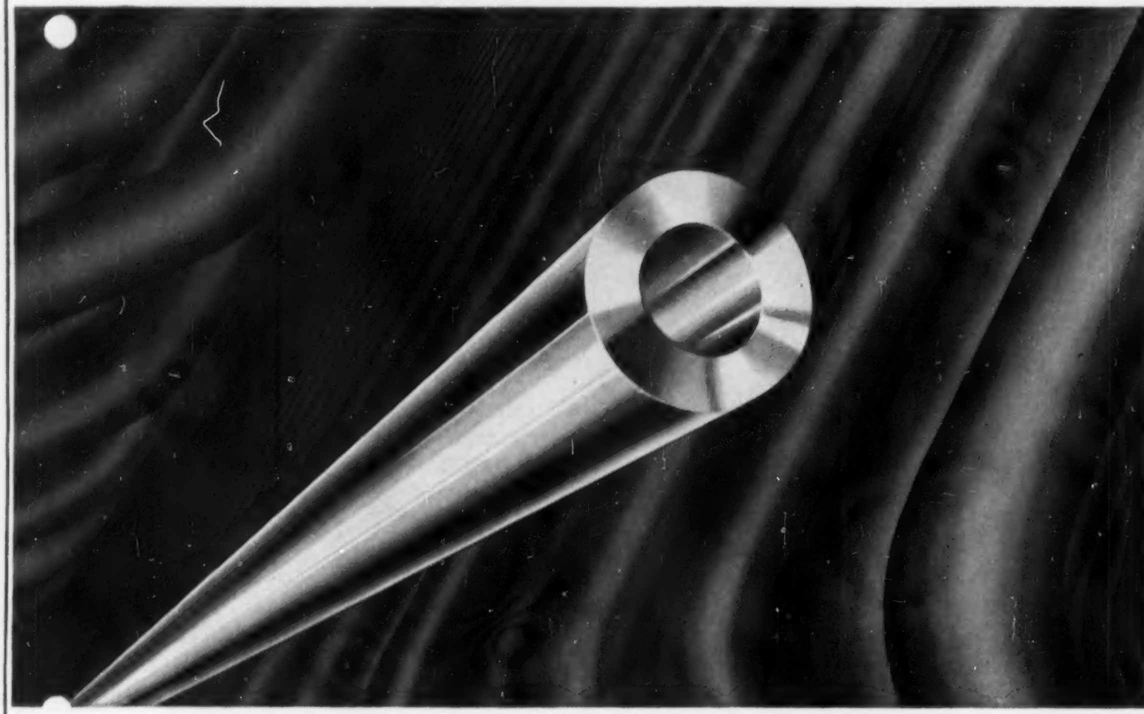
Current can be held constant to within 1% over a voltage range of 20 to 120 volts.

RADIO SIGNALS TRANSMITTED BY BOUNCING OFF METEOR TRAILS

High-frequency radio signals, bounced from meteor trails 60 to 100 miles above the earth, have been used experimentally for the first time to transmit images of printed material over a distance of nearly 1000 miles without relays. Special facsimile equipment has performed successfully in preliminary tests of meteor-path propagation between the transmitting station of the National Bureau of Standards at Havana, Illinois, and the RCA Laboratories radio research installation at Riverhead, Long Island. This is an airline distance of 910 miles.

Radio waves are reflected from ionized air particles, which are formed when a meteor enters the thin upper atmosphere of the earth. This trail of ionized air may persist during a time interval ranging from one-tenth of a second up to several minutes after the passage of the meteor. Along a transmission path of the type used in the experimental facsimile system, ionized meteor trails appear on an average of several times a minute to close the circuit between transmitter and receiver.

Tear out this page for **YOUR STEEL NOTEBOOK...**



The hole that couldn't be made will be 20 miles long

THE Philadelphia Electric Company set out to build a revolutionary new power plant that would squeeze more energy out of fuel than ever before. This meant harnessing the highest combination of pressure and steam temperature ever achieved in a central station—5,000 psi. and 1,200° F.

The boiler superheater tubes that carry this steel will glow red hot 24 hours a day, year in, year out. If made from the alloy steels customarily used, the tube walls would have to be so thick that no mill could pierce it. So thick that heat transfer losses would be ruinous to boiler efficiency. A super alloy steel was needed, but no one had ever succeeded in piercing such steel into tubes without developing internal flaws.

Combustion Engineering Co., designers and builders of the boiler, gave the problem to Timken Company metallurgists. The problem was to make the steel with all the alloys in just the right balance to produce piercing quality steel.

Thru metallurgical research, they achieved the proper balance of alloy elements that made it possible to pierce 20 miles of seamless superheater tubes of the size shown above. It's another example of how Timken Company metallurgists solve tough steel problems.

WANT TO LEARN MORE ABOUT STEEL OR JOB OPPORTUNITIES?

For information about fine steel, send for "The Story of Timken Alloy Steel Quality". And for help in planning your future, write for "BETTER-ness and Your Career at the Timken Company". Just drop a card to The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Stress & Strain

She: Why did you take up the piano?
He: My beer kept sliding off the violin.

• • •

The ice man smiled as his glance fell on this sign: "Please drive slowly. The child in the street may be yours."

• • •

Wisdom: Knowing what to do.
Skill: Knowing how to do it.
Virtue: Not doing it.

• • •

Bus driver: "All right back there?"
Feminine voice: "No, wait till I get my clothes on."
Then the driver led a stampede to the rear and watched the girl get on with a basket of laundry.

• • •

The young couple drove away on their honeymoon blissfully unaware of the sign their friends had put on the rear bumper: AMATEUR NIGHT.

• • •

C.E.: "Did Fifi blush when the strap on her bathing suit broke?"
Chem.E.: "I didn't notice."

• • •

A stenographer defines the wolf as a modern dry cleaner. He works very fast and leaves no ring.

• • •

How did mothers ever learn all the things they warn their daughters not to do?

• • •

Girls are just like cigarettes—a fact you must admit—You can't enjoy them fully until you get them lit.

• • •

She: "Look, mister, how long is this car going to keep stalling like this?"
M.E.: "Just as long as you do, baby."

• • •

Diplomat: A man who can convince his wife a woman looks stout in a fur coat.

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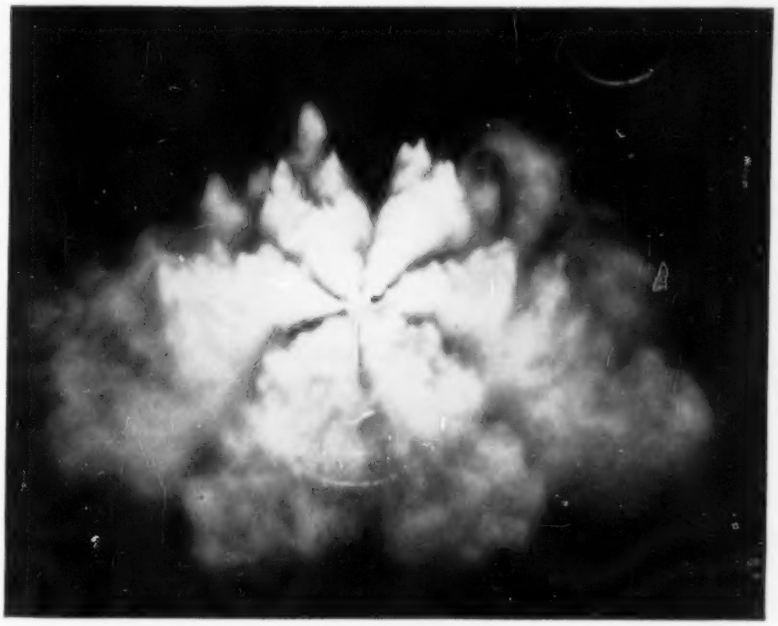
PHOTOGRAPHY AT WORK
No. 33 in a Kodak Series

The Army's first operational rotor-tip propelled jet helicopter—built by Hiller.



The camera has caught the fuel spray pattern within the rear end of the ram-jet engine even though passing by at about 450 miles per hour.

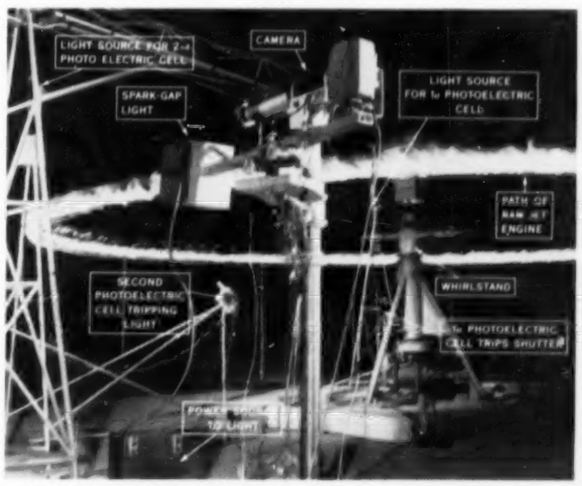
Project: Inspect rotor tip jets for a whirlybird

Hiller Helicopters wanted facts on the fuel spray pattern of a ram-jet engine whirling at speeds up to 700 feet per second. Photography got the job.

WHEN HILLER HELICOPTERS of Palo Alto, Cal.—a pioneer in vertical take-off aircraft—developed a rotor-tip ram-jet engine, they knew the fuel spray would be subject to high air velocity and centrifugal force up to 1200 G's. Would the fuel spray be deflected outward and cause the jet to lose thrust? They wanted to know. So they set up the camera with its fast eye to catch what otherwise couldn't be seen. And they learned the right angle of air intake and nozzle to obtain the greatest power.

Using photography in research is an old story with Hiller—just as familiar as using it for improving public relations. It's an example of the way photography plays many important roles in modern-day industry.

In whatever work you do you will find that photography will play a part in improving products, aiding quality control and increasing sales.



This is all the human eye could have seen of the whirling ram-jet engine as camera takes its picture.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADE MARK

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

One of a series*

Interview with General Electric's
W. Scott Hill
Manager—Engineering Recruiting

Qualities I Look For When Recruiting Engineers

Q. Mr. Hill, what can I do to get the most out of my job interviews?

A. You know, we have the same question. I would recommend that you have some information on what the company does and why you believe you have a contribution to make. Looking over company information in your placement office is helpful. Have in mind some of the things you would like to ask and try to anticipate questions that may refer to your specific interests.

Q. What information do you try to get during your interviews?

A. This is where we must fill in between the lines of the personnel forms. I try to find out why particular study programs have been followed, in order to learn basic motivations. I also try to find particular abilities in fields of science, or mathematics, or alternatively in the more practical courses, since these might not be apparent from personnel records. Throughout the interview we try to judge clarity of thinking since this also gives us some indication of ability and ultimate progress. One good way to judge a person, I find, is to ask myself: Would he be easy to work with and would I like to have him as my close associate?

Q. What part do first impressions play in your evaluation of people?

A. I think we all form a first impression when we meet anyone. Therefore, if a generally neat appearance is presented, I think it helps. It would indicate that you considered this important to yourself and had some pride in the way the interviewer might size you up.

Q. With only academic training as a background, how long will it be before I'll be handling responsible work?

A. Not long at all. If a man joins a training program, or is placed directly on an operating job, he gets assignments which let him work up to more responsible jobs. We are hiring people with definite consideration for their potential in either technical work or the management field, but their initial jobs will be important and responsible.

Q. How will the fact that I've had to work hard in my engineering studies, with no time for a lot of outside activities, affect my employment possibilities?

A. You're concerned, I'd guess, with all the talk of the quest for "well-rounded men." We do look for this characteristic, but being president of the student council isn't the only indication of this trait. Through talking with your professors, for example, we can determine who takes the active role in group projects and gets along well with other students in the class. This can be equally important in our judgment.

Q. How important are high scholastic grades in your decision to hire a man?

A. At G.E. we must have men who are technically competent. Your grades give us a pretty good indication of this and are also a measure of the way you have applied yourself. When we find someone whose grades are lower than might be expected from his other characteristics, we look into it to find out if there are circumstances which may have contributed.

Q. What consideration do you give work experience gained prior to graduation?

A. Often a man with summer work experience in his chosen academic field has a much better idea of what he wants to do. This helps us decide where he would be most likely to succeed or where he should start his career. Many students have had to work hard during college or summers, to support themselves. These men obviously have a motivating desire to become engineers that we find highly desirable.

Q. Do you feel that a man must know exactly what he wants to do when he is being interviewed?

A. No, I don't. It is helpful if he has thought enough about his interests to be able to discuss some general directions he is considering. For example, he might know whether he wants product engineering work, or the marketing of technical products, or the engineering associated with manufacturing. On G-E training programs, rotating assignments are designed to help men find out more about their true interests before they make their final choice.

Q. How do military commitments affect your recruiting?

A. Many young men today have military commitments when they graduate. We feel it is to their advantage and ours to accept employment after graduation and then fulfill their obligations. *We have a limited number of copies of a Department of Defense booklet describing, in detail, the many ways in which the latter can be done. Just write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.* 959-4

***LOOK FOR** other interviews discussing: • Advancement in Large Companies • Salary • Personal Development.*

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